

# ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

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# ANNALS of SURGERY

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## FINGER EXPLORATION OF GUNSHOT WOUNDS OF THE BRAIN\*

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### INTRODUCTION

OUR surgical team, while attached to Casualty Clearing Stations of the British First Army from May 12 to August 12, 1918, was designated to treat all wounds of the head admitted during a daily twelve-hour tour of duty. The casualties were received from a quiet sector in which no operations of major importance occurred, so that the Clearing Stations were not overworked, and it was never necessary to pass unoperated wounded along to the Base. That the opportunity for study of the cases was unusually favorable is indicated by the fact that the team operated only 262 casualties during the three months. The character, treatment, and mortality per cent. of the 61 head wounds is shown in Table I.

TABLE I  
*Analysis of Cases of Gunshot Wounds of Head*

|                                     | Number | Operated | Not operated | Died | Mortality % |
|-------------------------------------|--------|----------|--------------|------|-------------|
| Scalp wounds.....                   | 22     | 22       |              | 1*   | 4.5         |
| Fracture with intact<br>dura .....  | 11     | 11       |              | 1*   | 9.1         |
| Open dura with brain<br>wound ..... | 28     | 20       | 8            | 7†   | 35 } 53.6   |
| Totals .....                        | 61     | 53       | 8            | 17   | 27.9        |

\* Died of other cause than head wound.

† One died of other cause than head wound.

The 11 scalp wounds and 22 fractures with unopened dura brought out nothing of interest. The mortality in these cases is practically *nil* unless other wounds are fatal, as happened twice in this series. An intact

\* From U. S. Army Base Hospital No. 5.

dura was incised once, and that case is included with those in which the dura was opened by trauma.

This report is concerned with the 28 cases of wound of the brain of which 20 were operated and 8 were inoperable. The number of cases is limited, but a report seems justified for these reasons:

1. The series includes every case of gunshot wound of the head admitted from a given sector in alternate twelve-hour intervals. The British system of evacuation provides for no sorting of casualties short of the Clearing Station, so that every grade of wounded, sick, and gassed is received. Our figures have some interest as being fairly representative of the proportion of the various degrees of cranial injury that survive to reach a hospital some 15 to 20 kilometres from the line under the existing conditions.

2. We have been able to keep track of the 13 cases evacuated from the Clearing Station for periods of from six to twenty-one months after operation.

3. Some of the recent papers on brain wounds have condemned the use of the finger for palpating foreign bodies in brain cavities. For this most important step of the operation we believe that finger palpation is the most rapid, sure, and safe method of cleaning a wound large enough to admit a finger; and it is particularly on this point that we wish to present evidence.

The treatment of the wound in the brain tissue did not assume its true importance during the early years of the war. At first the general tendency, based on experience in previous wars in which bullet wounds predominated, was to abstain from operation. The disastrous results of this policy soon led to the conception that brain wounds should be opened widely and left open, and this was generally put into effect with more encouraging results. While dura and scalp were left open the method of cleaning the track attained relatively small importance, for, however thoroughly the metal, bone, and débris were removed, the wound was always subject to the danger of secondary infection during the long process of granulation and cicatrization, and one could never be certain whether the encephalitis in a given case was the result of imperfect cleaning or of infection from without. With the acceptance of the principle of primary suture of the scalp the situation became quite different, for if a brain wound operated early became septic under a sutured scalp it was clear that the track had not been properly cleaned. It was not until 1917 that suture came into its own, and then largely because it had been successfully applied primarily or secondarily to wounds of soft parts and of joints. There had been prophets before this, and largely without honor; as one looks back it seems extraordinary that the results of suture in the hands of Bárány,<sup>5</sup> Tabuteau,<sup>35</sup> and Velter<sup>36</sup> did not establish the method at once.

In the spring of 1918 we felt convinced, from previous experience and from the scanty available literature, that craniocerebral wounds should

## FINGER EXPLORATION OF BRAIN WOUNDS

be operated under local anæsthesia at the earliest possible moment, that damaged scalp and bone should be removed, that any evidence of skull injury demanded exploratory trephining, and that after cleaning of the track and removal, if possible, of foreign bodies the scalp should be closed. The open question was how the contaminated brain pulp, blood-clot, metal, detached bone fragments, cloth, and hair could be removed from the brain cavity surely, expeditiously, and without addition to the existing amount of brain damage. On this point we knew from experience with Cushing's team in the fall of 1917 (Cushing<sup>9, 10</sup>) that he opposed the use of the finger in the brain cavity, and advocated exploration with a soft rubber catheter and removal with forceps or magnet of the foreign bodies thus detected. This procedure was prolonged and tedious—Cushing says, "At best most of the critical operations deservedly require upward of a two-hour period"—and, more important, was sometimes unsuccessful in that it failed to remove all the foreign bodies. On the other side of the question we knew that Gray<sup>16</sup> and his followers were strong advocates of finger palpation in proper cases. For example, Anderson<sup>3</sup> says, "It is found that the brain does not suffer from careful exploration by the finger, if the hole in the dura permits of its introduction fairly easily."

A certain amount of personal experience, both pathological and clinical, had influenced our views on this question. A number of postmortem examinations of cases dying within twenty-four hours of injury impressed us strongly with the fact that it was a mistake to consider the brain lesion a *track* whose size was little, if any, greater than the diameter of the metallic fragment. The lesion was in reality a *cavity* in the brain tissue, with a diameter always considerably greater than that of the dural opening, which usually corresponded roughly to the size of the largest lodging foreign body. This cavity was somewhat egg-shaped, with the dural aperture at one pole, and the metal at the other, and with showered bone fragments lying free or embedded in its walls. The lesions observed in cases that died without operation indicated that, though the impulsion of bone fragments at angles lateral to the direct course of the metal was one reason for the increased diameter, the pressure of the hæmatoma which invariably filled the cavity caused additional lateral expansion. The same egg-shaped loss of substance was noted in lesions caused by indriving of bone fragments alone, and in the region of entrance of bipolar wounds—in fact, wherever bone fragments were found. We concluded that it was theoretically possible to palpate such cavities with the finger without any risk of causing additional injury to the surrounding uninjured brain tissue; and we felt that the prospect of being able to remove foreign bodies rapidly and completely was so desirable as to justify a trial, particularly as the method had been approved by surgeons of good standing. Therefore, it was used in a small series of unoperated cases which came into the hands of one of us (E. B. T.) in the fall of 1917. One case will be given to illustrate how the theoretical conclusions were confirmed.

## TOWNE AND GOETHALS

CASE A.—Pte. J. P. *Left parietal wound with prolapsed brain. Paralysis right arm and leg except for slight power in glutei. Paresis right face. Astereognosis right hand; loss of joint sense right fingers. X-ray—metal lodged in fractured skull, no indriven bone seen.*

*Operation* (October 15, 1917).—Ether. Tourniquet. Linear excision of scalp wound. Metal and bone fragments removed from brain fungus. Skull trephined and rongeur away to expose dural edge. Track cleaned by suction and irrigation with catheter and syringe. By Cushing's technic five pieces of bone were detected with the catheter and removed with forceps. When no more could be felt the finger was introduced through the dural opening and palpated the walls of an egg-shaped cavity 5 cm. deep. Two bone fragments, each over 1 cm. in diameter, were detected in the wall of the cavity and removed with forceps. Hæmostasis secured by irrigation with hot normal salt solution. Scalp closed with two gutta percha tissue drains between stitches.

*Post-operative Course.*—Motor and sensory condition on day after operation exactly as before. On fifth day there was improvement in face, deltoid, biceps, thigh muscles, and flexors of ankle. On tenth day there was motion in flexors of wrist and extensors of ankle. On fifteenth day all motions of arm and leg were performed with fair strength except at and below wrist and ankle, where they were weak. Face still weak. Wound healed. Evacuated to England October 29th. March 2, 1918; report from National Hospital, Queens Square, London (kindness of Dr. Fred S. Batten): "Wound sound, walks quite well, still has almost complete astereognosis of right hand. Power of right hand fair—right arm good. Except for this post central loss is quite well."

In three other cases foreign bodies were removed from cavities in the frontal lobe, temporal lobe, and cerebellum, and in each instance more bone fragments were detected by the finger after prolonged attempts to extract everything with catheter and forceps. These three also healed and were evacuated in good condition, and in none of them was there any evidence of increased brain damage after operation. The case detailed above was, however, the most encouraging evidence in favor of the finger technic, in that marked signs of injury to the motor tracts were not accentuated by operation, improved steadily, and disappeared almost entirely in four and one-half months.

### REPORT OF CASES

All wounds of the brain received at a forward hospital are not operable, nor do the operable cases all have large enough loss of cerebral substance to make finger palpation of the cavity possible. The 28 cases to be reported will therefore be classified under these headings:

1. Inoperable Cases (8). 2. Operated Cases (20).
- a. Cases in which finger palpation was not indicated (9).
- b. Cases in which finger palpation was or might have been used (11).

## FINGER EXPLORATION OF BRAIN WOUNDS

1. THE INOPERABLE CASES.—All but the obviously dying were operated, as it was felt that intervention without a general anæsthetic could do no harm, and might offer a chance of life to even the deeply comatose. As will be seen later, at least 3 of the operated cases were actually quite hopeless, but in a condition which appeared to justify intervention. Of the 8 cases which were not operated, 7 died in less than five hours, and 1 in ten hours after admission. All showed profound coma, a pulse of 110 to 140 which was weak and irregular, stertorous respiration which was frequently rhythmic, and loss of sphincter control; the majority were also sweating and frothing at the lips. One case will suffice to illustrate.

CASE I.—Rfm. A. B. Admitted June 10, 1918. *Large left parietal wound with prolapsed brain.* Deeply unconscious. Pulse 128, weak and irregular; Cheyne-Stokes respiration; froth on lips; skin moist and cold; involuntary urination. Dressed and sent to resuscitation ward, where he died two and one-half hours later. Autopsy: Extensive loss of substance left parietal lobe; track passing through lateral and third ventricle; large shell fragment at base in right middle fossa; bone fragments in left hemisphere and lateral ventricle.

2. THE OPERATED CASES.—*a. Those in Which Finger Palpation was not Indicated.* Widely different pathological conditions, such as areas of cortical laceration and hemorrhage covered by intact or punctured dura, tracks caused by very small metallic fragments which lodge or perforate, or inaccessible areas of brain damage caused by missiles passing through the deeper nasal sinuses, may come under this heading. In some of these conditions the treatment is quite simple, but in others, especially the lodged metallic fragments of small diameter and the brain wounds communicating with a nasal sinus, the prospect of encephalitis is always disturbing and its avoidance most difficult or even impossible. In this group are assembled 9 operated cases, 3 of which died.

CASE II.—Pte. B. W. *Area of laceration and hemorrhage in motor cortex under intact dura evacuated. Rapid amelioration of paralysis and aphasia. Weak face and mental changes twenty-one months later.* Admitted May 26, 1918, at 9 A.M. (five hours after injury). Conscious; pulse, 84; warm; severe headache.

*Wounds.*—(1) Crescentic scalp wound 3.5 cm. long, located 15/32 and 8 cm. to left.\* (2) Gutter wound with incomplete fracture left tibia. (3) Lodging wound right calf, large hæmatoma. X-ray—fracture skull, no metal; partial fracture right tibia with many small metallic fragments.

*Neurological.*—Twitching right face with central type paralysis. Paresis right arm; astereognosis right hand. Motor aphasia and agraphia; understands spoken and written words.

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\* By this method of localizing cranial wounds a base line is measured from nasion to inion (32 cm.), a perpendicular is run from it to the centre of the scalp wound (8 cm.), and the distance from the nasion to the point where the perpendicular intersects the base line is measured (15 cm.).

*Operation.*—May 26th, 11 A.M. (seven hours). (1) Novocaine and adrenalin. Scalp and pericranium excised; wound enlarged in three directions; flaps turned back. Shallow groove 1 cm. long in external table trephined, bone cut away to limits of fracture of internal table (3 cm. opening). Dura intact, tense, deep purple, and immobile. A 2 cm. linear incision was made, allowing a large amount of pulped brain and clot to extrude. Bleeding pial vessels secured with silver clips. Shallow cavity sucked clean and irrigated with hot saline solution. Dura, fascia, and skin sutured. No drainage. (2) Spinal anaesthesia. Wound left leg excised and sutured. Wound right leg excised, bone and metallic fragments removed; partly severed posterior tibial vein ligated, light gauze pack and splint.

*Post-operative Course.*—May 28th. Twitching of face rare. Hemiparesis unchanged. Can say a few simple words. Wounds clean. Scalp sutures removed. June 1st—No twitching face. Arm stronger. Chloroform; wound of right leg sutured; splint. June 2d—Cultures from right leg—no growth. June 4th—Talking better, able to write name and address. Right arm improving; can move right corner of mouth a trifle. Left leg healed, sutures removed. June 11th—Right leg healed, sutures removed. Talks and writes slowly and with mistakes, but with steady improvement. Right arm almost normal; right face weak. All wounds healed. No headache. Evacuated to Base.

*Later Reports.*—March 19, 1919 (nine and one-half months). Letter from patient, well written. Working in flax mill. Occasional mild headaches and dizziness. Right arm normal. Right corner of mouth droops a little. "I don't speak properly when tired." February, 1920 (twenty-one months). Letter from wife: Same status, except for four short periods when he was mentally deranged, thought her a German and threatened to kill her and himself.

*Comment.*—On the much debated question whether or not to incise an intact dura it seems to us that given a case under twelve or fourteen hours, there is very little danger of infection, and that the advantages of evacuating the pulped brain and hæmatoma and of securing the bleeding vessels are probably important though difficult to prove. Certainly in some instances it is necessary to check the hemorrhage if real danger of medullary compression is to be averted.

*CASE III.*—Pte. E. G. T. *Laceration of post-central cortex by bone fragments projected through dura. Slight residual motor and sensory loss eleven months later.* Admitted May 30, 1918, at 1 P.M. (ten hours after injury). Headache, dizziness, nausea, and three attacks of twitching in left arm without loss of consciousness. Pulse, 84; warm; rational.

*Wound.*—1 by 1.5 cm., its centre located 19/34 and 4 cm. to right. X-ray—metallic fragment in fractured skull.

*Neurological.*—Left-handed individual. Left arm weaker than right. Loss of common sensation left forearm. Astereognosis left hand. Loss of joint sense left shoulder, elbow, wrist, and fingers.



FIG. 1.—Case III. External and internal aspects of bone block and indriven fragments; a, burrap carried in by shell fragment. (Natural size.)

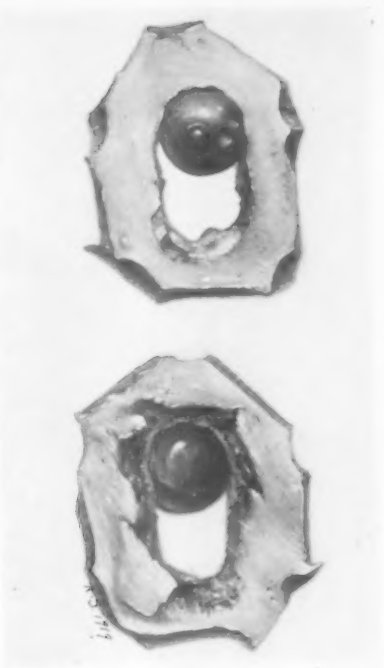


FIG. 2.—Case XIII. Lead shrapnel ball lodged in skull. (Natural size.)

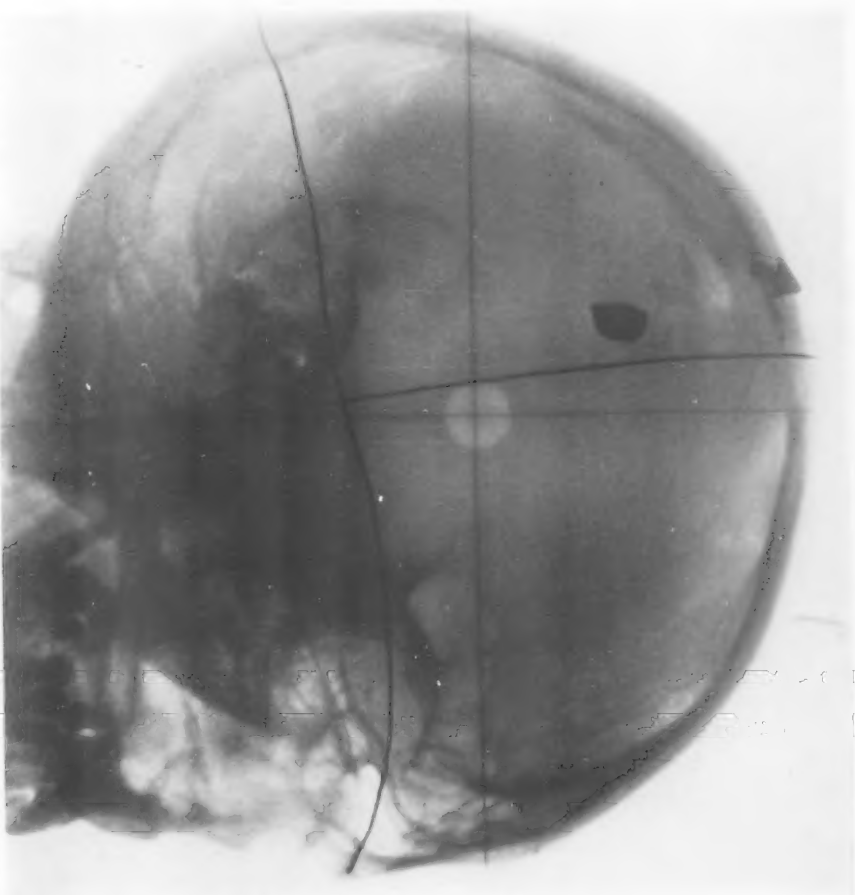


FIG. 3.—Case XV. Stereoscopically only four indriven bone fragments could be identified. (See Fig. 4.)



FIG. 4.—Case XV. Internal aspect of bone block and foreign bodies removed from brain cavity; *a*, metallic fragment—a piece of German helmet. (Natural size.)



FIG. 5.—Case XVI. Internal aspect of bone block, the larger bone fragments and (*a*) two views of the shell fragment. The metal and largest bone fragment were extracted from the lateral ventricle. (Natural size.)

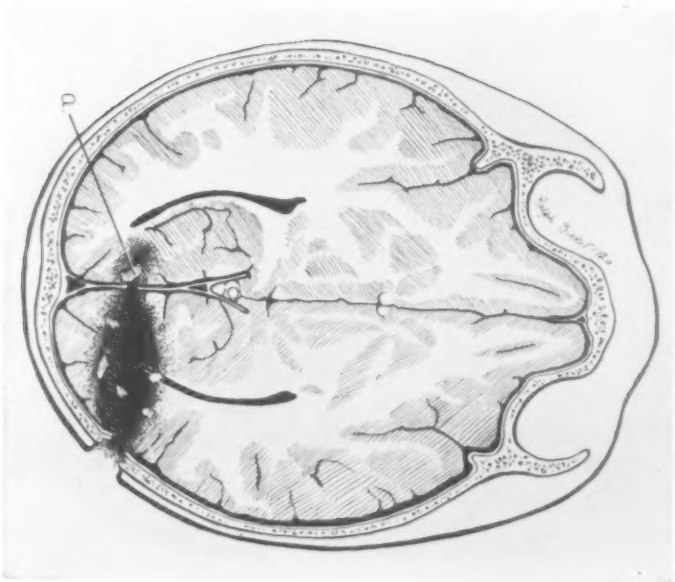


FIG. 6.—Case XVII. Diagrammatic horizontal section to illustrate egg-shaped cavity in right occipital lobe, with bone fragment in ventricle. Metallic fragment (d) was extracted through hole in falx.

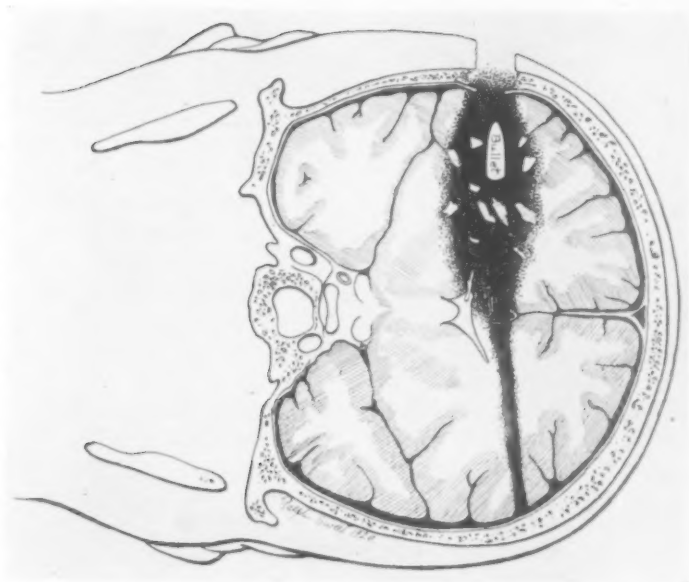


FIG. 7.—Case XXI. Diagram from sketch at autopsy. Note egg-shaped cavity in left hemisphere, open ventricle, severed anterior cerebral artery, and position of bullet before operation.



## FINGER EXPLORATION OF BRAIN WOUNDS

*Operation.*—May 30th, 5 P.M. (fourteen hours). Novocaine and adrenalin. Scalp wound excised and extended in three directions. The shell fragment had carried into the bone a piece of burlap helmet-cover (Fig. 1). Block of bone cut out, edges trimmed. Three pieces of bone, removed with forceps from just within a 1 cm. tear in dura, completed pattern of inner table. Small cortical cavity cleaned by suction and irrigation. Dura, fascia, and skin sutured. During operation there were three attacks of twitching of left arm, each lasting about thirty seconds.

*Post-operative Course.*—June 1st—Paresis of arm improving. Skin sutures removed. June 8th—Weakness of arm scarcely detectable. Joint sense of elbow and shoulder normal. Other sensory loss unchanged. Wound healed. No headache. Evacuated to Base.

*Later Reports.*—April 24, 1919 (eleven months). Letter from patient: In good health and working. Occasional headaches. Left arm a trifle weak, and "proper sense of feeling has not yet returned." No epilepsy.

*Comment.*—The only feature of interest is the good illustration of how contaminated foreign matter—in this instance a piece of the burlap which was so frequently used to cover "tin hats" in hot weather—may be carried in by a missile. The prognosis for continued freedom from epilepsy is dubious.

*CASE IV.*—Pte. S. C. S. *Deeply lodged small metallic fragment not recovered. Incapacitated by headache twenty months later.* Admitted June 7, 1918, at 10 A.M. (eleven and one-half hours after injury). Severe headache; pulse, 80; no neurological symptoms.

*Wound.*—0.5 cm. in diameter located 24/34.5 and 13 cm. to right. X-ray—a metallic fragment 0.3 by 0.7 cm. in midline half way between base and vertex.

*Operation.*—June 7th, 2 P.M. (fifteen and one-half hours). Novocaine and adrenalin. Scalp wound excised; small block of bone containing 0.5 cm. defect cut out. Pulped brain sucked out of track with small catheter, which passed in 10 cm. without detecting a foreign body or draining cerebro-spinal fluid. Dura and scalp sutured.

*Post-operative Course.*—June 8th—Severe headache. Spinal puncture, 40 c.c. of blood-stained fluid. Cultured—no growth. June 9th—Sutures out. June 11th—Severe headache; temperature and pulse normal, no tension in wound. Spinal puncture, 45 c.c. June 16th—Headache less severe. Wound healed. Evacuated to Base.

*Later Reports.*—February 16, 1920 (twenty months)—headache and dizziness quite severe; leading quiet life and not working on medical advice.

*Comment.*—The location of the wound and of the metallic fragment makes it practically certain that the lateral ventricle was involved, though this could not be confirmed at operation. Such cases are unsatisfactory in that they accomplish little beyond partially cleaning the track

and closing the coverings of the brain; it is then merely a matter of chance whether or not the foreign bodies cause sepsis.

CASE V.—Bdr. D. McM. *Laceration of temporal lobe by missile that passed through eye and maxillary sinus. Good result six months later.* Admitted August 12, 1918, at 2 A.M. (ten hours after injury). Good general condition; no neurological symptoms. Wound of right face; eye destroyed, malar bone and floor of orbit fractured. X-ray—large metallic fragment in right sphenomaxillary fossa.

*Operation.*—August 12th, 4 A.M. (twelve hours). Chloroform. Eye enucleated; fractures of malar bone and floor of orbit regulated; metal removed. Fragments of fractured great wing of sphenoid picked out. Catheter passed into a temporal lobe cavity which was sucked as clean as possible. No indriven bone felt; finger palpation not possible. Gutta percha tissue drain to dura through stab wound in temporal muscle. Fractured malar bone replaced by suturing periosteum; plastic closure of cheek and eyelids.

*Later Reports* (not seen after operation).—Letter from Medical Officer who took charge of patient; "evacuated to Base September 2, 1918, in good condition with apparently complete recovery." February 23, 1919 (six months)—reply card from hospital in Scotland. "Pus in eye socket on admission. Antiseptic lotions, massage. Sent on extended leave. Result: Socket clean and cheek swelling down."

*Comment.*—Favorable results in these nasal sinus cases are largely a matter of good fortune, for the brain cavity usually cannot be properly cleaned and is, moreover, exposed to secondary infection.

CASE VI.—Pte. J. G. *Unsuspected exit wound over occipital lobe; entrance not identified. In hospital because of headache six months later.* Admitted August 9, 1918, at 9 P.M. Good general condition; conscious and irritable. No neurological signs. Multiple small wounds of scalp, face, thighs and legs. X-ray—no metal in head.

*Operation.*—August 9th, 11 P.M. (interval not noted). Chloroform. Two scalp wounds excised and sutured. A third, over right side of occipital bone above inion, exposed a 0.6 cm. bone defect which was obviously an exit wound, as there were bone fragments in the scalp. Opening enlarged; catheter passed 3 cm. along a track directed toward left ear when it met obstruction (falx?). Dura and scalp closed. Metal removed from thigh and leg wounds.

*Post-operative Course.*—August 12th—Wounds clean; temperature and pulse normal; rational and irritable. Reëxamination discloses no entrance wound of left face, neck or mouth. No hemianopsia on rough test. (Not seen after this date.)

*Later Reports.*—March, 1919 (six months)—letter from patient. In hospital in England. Wounds healed. Under treatment for "periodical pains in the head."

CASE VII.—Pte. F. W. *Wound perforating right cerebellum. Evacuated to England as walking case sixth week. Working twenty*

## FINGER EXPLORATION OF BRAIN WOUNDS

*months later.* Admitted June 15, 1918. Good condition; conscious and irritable.

*Wounds.*—Entrance right cheek; exit half way between right external auditory meatus and inion, at level of meatus. Bone fragments in scalp; prolapse of brain tissue.

*Neurological.*—Right seventh nerve branch to forehead paralyzed; right ear deaf; dizzy; slight dysarthria.

*Operation.*—June 15th (ten hours). Novocaine and adrenalin. Exit wound excised; margins of bone defect regulated; track in cerebellum sucked and irrigated; scalp sutured with small gutta percha tissue drain to dura.

*Post-operative Course.*—June 17th—Sutures and drain removed. Moderate headache. June 23d—Neurological signs unchanged; wounds healed; no headache. Evacuated to Base.

*Later Reports.*—July 23, 1918, from Base in France. "Evacuated (that day) as walking case. Walks well with slight shuffling right foot. Speech much clearer. Ataxia of right hand much less. Very little dizziness or headache." February, 1920 (twenty months), by letter from Colonel Gordon Holmes: right ear deaf; infrequent severe headaches; right hand useful "except for little things that require a light touch" (patient's words).

*The Fatal Cases.*—Three cases in Group A resulted in death. The first did not die of his brain wound.

CASE VIII.—Pte. G. H. *Multiple wounds, including depressed fracture temporal bone with cortical laceration by indriven bone fragments. Death from post-pleuritic empyema. Brain wound clean.* Admitted June 9, 1918 at 8 A.M. (seven hours after injury). Semi-conscious, restless, and noisy; pulse 104, poor quality; no neurological symptoms.

*Wounds.*—(1) Over nasion, M.F. felt in left orbit; left eye destroyed. (2) Four right parieto-temporal scalp wounds, under one of which, just above auricle, fractured bone is seen. (3) Two lodging wounds right shoulder. X-ray—fracture right temporal bone; metallic fragments in right deltoid and supraspinatus and in left orbit.

*Operation.*—June 9th, 11 A.M. (ten hours). Chloroform. (1) Right parietal and temporal scalp wounds excised; depressed fracture temporal bone trephined; small dural tear enlarged, three fragments of bone removed with forceps from under dura; area of contusion cleaned; dura sutured; plastic scalp flap. (2) Nasion wound excised and extended along left supraorbital ridge. Fracture into left frontal sinus regulated; mucous membrane curetted out of sinus. Left eye enucleated; metal removed from orbit. (3) Metal and damaged tissues removed from right shoulder region.

*Post-operative Course.*—Normal as concerns wounds, which were all clean. June 11th—Pleurisy right chest. June 13th—Pus aspirated from chest. June 17th—Doing badly despite daily aspirations. June 18th—Empyema drained. June 23d—Died.

*Autopsy.*—Area of laceration in right temporal lobe clean and

covered with healed dura and scalp. A little pus in left orbit; frontal sinus clean. A 2 cm. area of organizing hemorrhage in left parietal cortex (contrecoup). Shoulder wounds clean. Right empyema and lung collapse; small abscesses near surface of lung.

CASE IX.—Sapper G. A. F. *Small metallic fragment, penetrating frontal sinus, third ventricle, and basal ganglia, not extracted. Death fifth day from ventriculitis.* Admitted July 22, 1918, at 3 P.M. Semi-conscious, irritable, and noisy; pulse 80 and fair quality; no neurological symptoms.

*Wound.*—Small puncture through left eyebrow. X-ray—metallic fragment 0.4 by 0.8 cm. lying 2.5 cm. posterior to dorsum sellæ and 3 cm. to right of midline.

*Operation.*—July 22d, 6 P.M. (interval unknown). Chloroform. Scalp wound excised and extended. Anterior wall of left frontal sinus removed; mucous membrane curetted out of sinus; opening in posterior wall of sinus enlarged. Small catheter sucked track to depth of 6 cm. without detecting a foreign body. At one point a few c.c. of blood-stained fluid were aspirated from a ventricle. Scalp sutured.

*Post-operative Course.*—July 24th—Extremely noisy and irrational. Temperature and pulse normal. July 27th—Temperature 101°, pulse 150, respiration 32. Chest negative. Incontinence of urine. Wound healed. Spinal puncture; 20 c.c. of yellow clear fluid (pure culture streptococcus). Died 9 P.M.

*Autopsy.*—Frontal sinus clean; fronto-nasal duct open. No gross meningitis or encephalitis. Two small bone fragments just below dural opening. Track passed through left frontal lobe, crossed midline above optic chiasm, and traversed third ventricle. Metal lay between right crus and optic thalamus.

*Comment.*—The gross appearance of meninges and brain was so normal that but for the streptococci in the spinal fluid the death might have been attributed to midbrain injury. The striking similarity between this and Case IV, which recovered, shows how large an element chance plays in the results of these imperfectly cleaned cases.

CASE X.—Pte. T. F. *Perforating wound through nasal sinuses and temporal lobe. Death eighth day from meningo-encephalitis.* Admitted August 10, 1918, at 8 P.M. Semi-conscious and irritable; bleeding from nose; no paralysis; left pupil dilated and fixed; pulse 76 and good quality.

*Wounds.*—Perforating, right cheek to above left zygoma, with blown-out bone fragments in left temporal muscle.

*Operation.*—August 10th, 10 P.M. (interval not known). Chloroform. Damaged scalp and temporal muscle excised. Finger palpated a fracture of great wing of sphenoid at base but could not reach area of brain laceration. Catheter introduced and suction applied. Wound sutured with gutta percha tissue drain to dura. Cheek wound excised and sutured.

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*Post-operative Course.*—August 12th—Rational, drowsy. Temperature and pulse normal. (Not seen after this date; further information from Medical Officer who took charge of case.) August 16th—Headache, rising temperature and pulse. August 18th—Died.

*Autopsy.*—Track through infected right maxillary sinus, floor of nose, left maxillary sinus. Fracture of left great wing of sphenoid. Abscess in left temporal and frontal lobes. Meningitis over entire left cerebral hemisphere.

*Comment.*—Case V, which did not become septic, had almost the same pathology and treatment. There appears to be no way to reduce the risk which patients with such awkwardly situated brain lesions must undergo.

b. CASES IN WHICH FINGER PALPATION WAS OR MIGHT HAVE BEEN USED.—Under this heading there are 11 cases, of which 7 recovered and 4 died. In all but one finger palpation was used, and that one, which follows, was the only instance of infection and brain fungus which occurred among the cases in which the foreign bodies were within reach of the finger.

CASE XI.—Pte. E. W. *Cavity in frontal lobe imperfectly cleaned by Cushing's technic. Infected fungus cerebri. Severe epilepsy began twelve months later.* Admitted May 13, 1918, at 9 A.M. (twelve and one-half hours after injury). Cold, semi-conscious, and irrational; pulse 80 and poor quality; no neurological symptoms.

*Wound.*—A narrow gutter 5 cm. long following hair line in right frontal region. Brain tissue prolapsed. X-ray—indriven bone, no metal. Sent to resuscitation ward. At 2 P.M. warm, conscious, with good pulse of 90.

*Operation.*—May 13th, 3 P.M. (eighteen and one-half hours). Novocaine and adrenalin. Scalp wound excised and extended in three directions exposing 1 by 4 cm. defect in frontal and temporal bones. Edges rongeuired to uncover margins of a 3.5 cm. tear in dura. By patient's efforts, suction, and irrigation, pulped brain and clot were evacuated from a cavity 4.5 cm. deep. Seven bone fragments with diameters .5 to 1.5 cm. were detected with catheter and removed with forceps. The finger was not introduced. Scalp closed with gutta percha tissue drain to dura.

*Post-operative Course.*—May 16th—Sutures and drain removed. May 18th—Small fungus through scalp at junction of flaps; temperature and pulse normal. Spinal puncture, 30 c.c. clear fluid (no growth). May 20th—Pus from drainage wound grew streptococci, staphylococci, and B. Welchii. May 23d—Fungus 2 cm. in diameter and level with skin, discharging small bone fragments. May 31st—Fungus receding and granulating. No headache. Temperature and pulse normal. Evacuated to Base.

*Later Reports.*—June 15, 1918, from Base in France: "Moderate infection of granulating surface. One or two small spicules of bone picked out. No intracranial symptoms." February 23, 1919 (nine and one-half months); letter from patient—Unable to resume work as miner because of dizziness when stooping. Otherwise perfectly well.

January 9, 1920 (twenty months); letter from sister—General epilepsy without aura began May, 1919; attacks once a month lasting five minutes. Face severely burned during convulsion in December, 1919.

*Comment.*—In spite of the fact that we were convinced that such a brain cavity, especially in a silent area, could be properly cleaned by the finger technic without risk of further brain damage, we felt impelled to try the catheter method once more. The notes do not give the time consumed in the procedure, but it was very long and tedious. This was our first Clearing Station case in which the finger might have been used, and the only one in which we failed to use it. The six and one-half hours delay between admission and operation was not wise or necessary; we soon discovered that a man in like condition could usually be warmed and made ready for operation in an hour by the application of external heat and the administration of hot drinks. Whatever influence the eighteen and one-half hour interval may have had (and it was probably not important, for similar cases operated after fourteen to sixteen hours and completely cleaned did not become septic), the fact remained that we had failed to remove all the bone fragments, and that the man recovered only because he was able to take care of his sepsis. The next case offers an interesting contrast.

*CASE XII.*—Pte. J. P. *Cavity in frontal lobe from tangential wound involving frontal sinus cleaned under finger control. Free from discomforts and working twenty months later.* Admitted May 16, 1918, at 9 A.M. (five and one-half hours after injury). Condition good; restless and irritable; right eye blind.

*Wound.*—Through middle of right eyebrow, oozing brain tissue. Large metallic fragment felt under scalp.

*Operation.*—May 16th, 11 A.M. (seven and one-half hours). Chloroform. Triradiate incision; bone defect enlarged to uncover dural margins; loose fragments of roofs of right orbit and frontal sinus removed; mucous membrane curetted out of frontal sinus. After suction and irrigation of a cavity 4 cm. deep, the finger was introduced and five pieces of bone were removed from its depths with forceps. Scalp sutured with gutta percha wick to dura.

*Post-operative Course.*—May 17th—Ectropion of right upper lid. Right pupil dilated with atropin. May 19th—Sutures and wick removed. May 22d—Two short general convulsions. May 23d—Drowsy, complains of headache. Spinal puncture, 45 c.c. May 27th—Right eye counts fingers; can almost close right eyelids. No headache; wound healed. Evacuated to Base.

*Later Reports.*—May 29, 1918, from Base Hospital in France: "No headache—extensive hemorrhages in right vitreous." February, 1919, and January, 1920 (twenty months), letters from patient's father—Working as warehouseman in a factory; almost no vision right eye; "he is in splendid health and spirits."

*CASE XIII.*—Pte. F. G. W. *Laceration of speech area by bone fragments projected from a tangential wound. Finger technic. Jack-*

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*sonian epilepsy began tenth month.* Admitted July 27, 1918, at 6 A.M. (seven hours after injury). Severe headache; good general condition.

*Wound.*—Left parietal (not localized). No brain tissue seen. X-ray—shrapnel ball in fractured skull.

*Neurological.*—Alexia, agraphia, impaired understanding of spoken word, and slow groping speech.

*Operation.*—July 27th, 11 A.M. (twelve hours). Novocaine and adrenalin. Triradiate incision, exposing a lead shrapnel ball lodged at one end of a gutter defect (Fig. 2). Block of bone excised; eleven extradural bone fragments removed. There were two small openings in a tense, purple, immobile dura. A connecting incision was made, allowing a quantity of pulped brain and clot to extrude. Suction and irrigation of a shallow cortical defect; finger palpated three bone fragments embedded in the wall of the cavity, which were removed. Pial vein ligated with clip. Dura, fascia, and skin sutured.

*Post-operative Course.*—July 29th—Headache, wound rather tense. Spinal puncture, 40 c.c. (no growth). Speech defects unchanged. Skin sutures removed. August 7th—Wound healed, no headache. Alexia unchanged; can write alphabet; speech hesitating because of difficulty in remembering words; understands spoken word perfectly. Evacuated to Base.

*Later Reports.*—Letters from patient and his mother. November, 1918 (four months), went to work as miner underground. Aphasic condition entirely gone. May, 1919 (ten months), minor convulsions involving right side. June, 1919, a cranioplasty was done. August, 1919, a series of severe general convulsions, apparently focal in right arm; returned to hospital. January, 1920 (seventeen and one-half months), working above ground. Major convulsions every six weeks, ushered in by herniation at defect where graft has not united. Medicines have had no effect. "Very bright and cheerful" between attacks. Awaiting word to return to hospital, where he believes bone graft is to be attempted again.

*Comment.*—The interesting point in this case is the epilepsy following suture of the dura. It would seem unwise to allow a man with a wound so near the motor cortex to attempt the heavy work of a miner. On the question of cranioplasty, it is difficult to see how one could expect to cure or improve epilepsy by repairing a skull defect. One of Guillain's<sup>19</sup> conclusions, as adopted by the Society of Neurology of Paris, was that cranioplasty is contraindicated if the patient shows partial or general epileptic phenomena. In this instance the convulsions became much more severe and frequent after the attempted repair, but it is impossible to say that the course would not have been the same without operation. It seems unlikely, in view of the history of herniation of a tense brain with the onset of the attacks, that the patient is correct in thinking that cranioplasty is to be again attempted; probably the dead graft is to be removed.

CASE XIV.—Pte. E. D. *Shallow temporal lobe cavity containing foreign bodies contaminated with gas bacillus and streptococcus. Flap*

*operation; finger technic. Working as miner twenty months later.* Admitted June 12, 1918, at 10 A.M. (eleven and one-half hours after injury). Headache and nausea; condition good; no neurological symptoms.

*Wound* circular, 1 cm. in diameter, located 2.5 cm. anterior to right tragus and 2 cm. above zygoma. X-ray—shrapnel ball in temporal lobe.

*Operation.*—June 12th, 2 P.M. (fifteen and one-half hours). Novocaine and adrenalin. Entrance wound excised. Flap of scalp and temporal muscle turned down to zygoma, uncovering extensive fracture of squamous portion of temporal bone. Bone fragments removed; edges regulated. One large and two small dural perforations. Bleeding middle meningeal artery ligated with a clip. Dural wounds connected; cavity 3 cm. deep sucked and irrigated; metal and four bone fragments removed under finger control; dura sutured; gutta percha drain to dura through stab wound at upper margin of zygoma; entrance and operative wound closed in layers. Shrapnel ball cultured—"Gram positive bacillus of Welchii type and streptococcus."

*Post-operative Course.*—June 14th—Sutures and drain removed. June 23d—Wounds healed. No discomforts. Evacuated to Base.

*Later Reports.*—Letters from patient. February 28, 1919 (eight months), "I am working under ground in the mines—sometimes I suffer with slight Headakes when I work to Hard, otherwise I feel Champion." February, 1920 (twenty months)—Frequent headache and dizziness, but continues at work.

*Comment.*—This case was a revelation of the possibilities of local anæsthesia. Turning down the entire temporal muscle in a heavily muscled man is a troublesome and bloody procedure under general anæsthesia, but with novocaine and adrenalin there was no bleeding except from a few large branches of the superficial and deep temporal arteries, and absolutely no pain. The ominous bacteriology of the missile confirmed once more the absolute necessity of thorough removal of foreign bodies and damaged tissues.

*CASE XV.*—U/Off. B. S. (prisoner of war). *Deep parietal cavity cleaned under finger control; motor loss slightly increased for twelve days after operation; rapid return thereafter. Repatriated ten months later.* Admitted June 18, 1918, at 4 P.M. (eight hours after injury). General condition good.

*Wound.*—Two cm. in diameter, located 17/34 and 7 cm. to right; brain tissue extruding. X-ray—thin metallic fragment 1 by 1.5 cm. and three or four medium-sized pieces of bone deep in parietal lobe (Fig. 3).

*Neurological.*—A left-handed individual. Central type weakness of left face. Left arm—motions at shoulder slightly subnormal; at elbow one-half normal; slight flexion and no extension of wrist and fingers. Left leg normal. Common sensation lost, roughly, below left elbow. Astereognosis of hand, and loss of joint sensation of elbow, wrist and fingers on left. Speech slightly slowed and blurred. Exaggerated deep reflexes on left.

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*Operation.*—June 18th, 7 P.M. (eleven hours). Novocaine and adrenalin. Triradiate incision; block of bone about defect excised. Cavity cleaned by patient's efforts, suction and irrigation. The 1 cm. aperture in the dura, not wide enough to admit the index finger, was enlarged in its long axis. The finger palpated an egg-shaped cavity 4 cm. deep and about 2.5 cm. wide in its greatest diameter. Metal, seven bone fragments of medium size, and many smaller ones removed under finger control (Fig. 4). Some bone spicules were so firmly embedded in the walls of the cavity that they were identified and freed with difficulty. Dura sutured as far as possible; fascia and skin closed. Duration of operation thirty minutes. Metal and bone fragments cultured (no growth).

*Post-operative Course.*—At end of operation there was no flexion of left fingers or wrist; elbow movements were slightly weaker than before, and the paraphasia was a little more marked. June 20th—No aphasia or weakness of left face; arm as after operation. Spinal puncture, 40 c.c. Sutures removed. June 24th—Left arm improving; at shoulder and elbow same as before operation, at wrist very slight flexion and no extension. July 1st—Left arm back to exactly same power as before operation. July 11th—All motions left arm definitely stronger than before operation. Identifies pin point above wrist. July 16th—Left arm: No demonstrable weakness at shoulder; slightly below normal at elbow; flexion of wrist and fingers one-half normal, extension one-quarter normal. Sensory loss was the same as on July 11th. Wound healed; no headache. Evacuated to Base.

*Later Reports.*—From Medical Research Committee—admitted to hospital in England August 10th; discharged to Prisoners of War Camp September 12, 1918; repatriated April 10, 1919. No medical report obtainable.

*Comment.*—This was the only case in which routine examination immediately after operation showed any evidence of further brain injury attributable to the operative procedure. The increased palsy was slight but definite; in twelve days it had come back to the condition that was present on admission; and in four weeks there was at least a 50 per cent. improvement over motor power before operation. It is impossible to tell, in a given case, whether the paralysis is entirely due to a destructive lesion of the motor cortex or path, or if not, what portion of it is due to concussion and œdema. Certainly in this instance concussion, œdema, and hemorrhage into the brain cavity caused a considerable part of the palsy, and a part that was recoverable. We feel that any trauma superadded by careful use of the finger is recoverable, and justified by the absolute insurance against brain sepsis which the procedure gives. The case presents another point of interest. Excellent stereoscopic radiographs showed only about half the medium-sized bone fragment recovered (Figs. 3 and 4). It has been our experience that not more than 75 per cent. of fragments with a diameter above 0.5 cm., and practically none

below that size, could be demonstrated radiographically. It would not seem wise to be content, if cleaning a cavity without finger control, with removing the number of fragments diagnosed by the X-ray. It is unfortunate that no further news of this man's physical condition after he was evacuated could be obtained. The fact that he was discharged from Hospital to P. O. W. Camp three months after operation suggests that progress was satisfactory.

**CASE XVI.**—Pte. H. P. *Parietal cavity with hemiplegia. Metal and bone extracted from lateral ventricle under finger control. Residual hemiplegia nine months later.* Admitted June 12, 1918, at 6 A.M. (five and one-half hours after injury). Semi-conscious; rational when aroused; general condition fair.

*Wound.*—One cm. in diameter, located 18/32 and 10 cm. to right. X-ray—metal and bone in right cerebral hemisphere.

*Neurological.*—Complete left hemiplegia; anæsthesia and spasticity of left arm and leg.

*Operation.*—June 12th, 10.30 A.M. (ten hours). Novocaine and adrenalin. Triradiate incision; block of bone excised. During catheter cleaning of a track 7 cm. deep blood-stained cerebrospinal fluid was aspirated. At full length of index finger the metal and a large bone fragment were extracted from the lateral ventricle; another large and many small pieces of bone were removed from the walls of the cavity (Fig. 5). Scalp sutured, with gutta percha tissue wick to dura. Metal and bone cultured—"Gram positive bacillus of Welchii type."

*Post-operative Course.*—June 14th—Sutures and wick removed. Spinal puncture, 30 c.c. (no growth). June 16th—Wound rather tense; spinal puncture, 40 c.c. (no growth). June 24th—Motion returning in left face. Left arm and leg massaged daily. July 3d—Face improving slowly; arm and leg remain paralyzed and anæsthetic. Wound healed; no headache. Evacuated to Base.

*Later Reports.*—March 6, 1919 (nine months); letter from patient's mother—"He is paralyzed in the left side but going on ever so well."

**CASE XVII.**—Cpl. A. G. S. *Destruction of right occipital lobe involving ventricle; metal extracted under finger control through falx from left occipital lobe. Recovery with hemianopsia.* Admitted May 26, 1918, at 11 A.M. (twelve hours after injury). Semi-conscious; restless; fair general condition.

*Wound.*—Two by 3 cm. in diameter, located 28/34.5 and 7.5 cm. to right; prolapsed brain. X-ray—metallic fragment in left occipital lobe; two bone fragments to right of midline.

*Neurological.*—Blind; no pupillary reaction; spastic legs.

*Operation.*—May 26th, 3 P.M. (sixteen hours). Novocaine and adrenalin. Triradiate incision; excision of block of bone about defect, exposing 2 cm. hole in dura. After usual removal of pulped brain and clot, the finger palpated a large oval cavity into which the posterior horn of the ventricle opened. One piece of bone extracted from ventricle, and four others from the wall. The finger then detected

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a small hole in the falx cerebri. The external dural defect was enlarged to allow a catheter to pass in beside the finger, which guided it through the aperture in the falx where it grated on a foreign body (Fig. 6). Forceps were introduced along the catheter into left hemisphere; the metallic fragment (a piece of helmet) was seized and extracted. Dura partly closed; scalp sutured with small gutta percha wick to dura. Metal and bone cultured (no growth).

*Post-operative Course.*—May 27th—Very restless and irrational. Spinal puncture, 40 c.c. (no growth). May 28th—Alternate restlessness and drowsiness. Wick and sutures removed. June 4th—Headache; wound tense; spinal puncture, 45 c.c. June 10th—Electric light flash detected. June 12th—Wound full; spinal puncture, 45 c.c. Counts fingers in right visual fields. June 13th—Identifies by vision watch, pencil, etc. June 15th—On rough test, returning vision in right upper quadrants only. Pupils react to light. Wound healed; no headache. Evacuated to Base.

*Later Reports.*—Notes from Discharge Documents, January 27, 1919 (kindness of Medical Research Committee). Visual acuity normal; left hemianopsia and lower altitudinal hemianopsia; difficulty in judging distance and position; frequent severe headaches; nervous apprehensive gait; spastic legs. January 4, 1920 (nineteen and one-half months); letter from patient. Periods of headache and dizziness; occasional attacks of petit mal. Walks cautiously with aid of stick because of limited visual fields. Apprehensive about skull defect and wants advice about cranioplasty.

*Comment.*—This case brings out, better than any other, the advantages of the use of the finger. It is most unlikely that the bone fragment in the ventricle could have been detected and removed by any other method; and it is certain that, except by palpation, location of the hole in the falx and extraction through it of the metal would not have been possible.

*The Fatal Cases.*—There were four post-operative deaths in Group B.

CASE XVIII.—J. B. M. (aged French civilian). *Extensive destruction of cerebral hemisphere. Death in forty hours from brain injury.* Admitted June 5, 1918, at 9 A.M. Deeply comatose; pulse, 102; probable left hemiplegia.

*Wound.*—Tangential, above right pinna; prolapsed brain. X-ray—fractured skull, no metal.

*Operation.*—June 5th, 1 P.M. (interval unknown). Triradiate incision, block of bone including gutter defect excised; large parietal cavity cleaned of pulped brain, bone and hair; scalp closed.

*Post-operative Course.*—June 7th—Died without regaining consciousness forty hours after operation. Wound clean. No autopsy.

*Comment.*—With greater experience this case would have been passed as inoperable.

CASE XIX.—Sec. Lieut. B. *Extensive destruction of both frontal lobes; fractures involving nasal sinuses. Death fourth day.* Admitted

June 5, 1918 (one-half hour after injury). Unconscious; pulse, 100; no paralysis.

*Wound.*—Extensive; 5 cm. above outer canthus of left eye; brain extruding. X-ray—large metallic fragment in right orbit.

*Operation.*—June 5th (five hours). Novocaine and adrenalin. Triradiate incision; large bone defect with radiating fissures regulated; many bone fragments removed under finger control from extensive cavity in frontal lobes; scalp sutured.

*Post-operative Course.*—June 6th—Unconscious; incontinent. June 7th—Wound clean, sutures removed. Metal removed from right orbit under light ether anaesthesia (Captain Haycroft). June 8th—No return of consciousness; temperature, 100°; pulse, 120; rhythmic respirations. Spinal puncture, 90 c.c. (no growth). June 9th—Died at 3 P.M.

*Autopsy.*—Sutured wound clean. Entire frontal bone shattered; fissures into both orbits, parietal bones, sphenoid bone, and cribriform plate of ethmoid. Anterior poles of both frontal lobes destroyed; longitudinal sinus divided; no bone fragments except in right orbit. No evidence of sepsis, no hemorrhage.

*Comment.*—This was apparently a delayed death from brain injury, though the possibility of acute streptococcus encephalitis cannot be ruled out in the absence of cultures of the brain at autopsy.

CASE XX.—L/Cpl. W. K. *Metal lodged in posterior fossa after traversing left cerebrum, lateral ventricle and right cerebellum not removed. Death ninth day from encephalitis and ventriculitis.* Admitted May 13, 1918, at 10 A.M. Deeply unconscious, cold, with poor pulse of 100. After application of heat pulse came down to 86, fair quality.

*Wound.*—Circular, left parietal, extruding damaged brain. X-ray—shrapnel ball in right posterior fossa.

*Neurological.*—Probable right hemiplegia; eyes deviated to left.

*Operation.*—May 13th, 2 P.M. (interval unknown). Novocaine and adrenalin. Triradiate incision and block trephine. Ten bone fragments removed from large parietal cavity and lateral ventricle under finger control. Scalp sutured.

*Post-operative Course.*—May 16th—Appears to understand; motor aphasia and right hemiplegia; taking fluids. Wound tense; spinal puncture, 40 c.c. May 18th—Temperature, 101°; pulse, 120. Disorganized brain (culture: streptococcus and staphylococcus) oozing between sutures. Wound opened. May 20th—Less aphasic. Small brain fungus. Temperature 100°; pulse, 112. May 22d—Died after rapid rise of temperature to 104°, pulse to 160, and respiration to 42.

*Autopsy.*—Generalized meningitis; thin pus in ventricular system. Track through left ventricle, corpus callosum, and right cerebellum; shrapnel ball resting on dura. No bone fragments found in parietal cavity, ventricle, or cerebellum.

*Comment.*—This man died of sepsis and might have lived, in spite of the extensive brain damage, if the track could have been thoroughly cleaned. The operation was insufficient; we should have trephined the

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right occipital bone and cleaned the cerebellar track. The result might have been the same, but everything possible would then have been done and the chances of sepsis would have been reduced.

*CASE XXI.*—Sgt. H. N. *Bullet traversed both cerebral hemispheres and lodged near entrance wound. Death from hemorrhage same day.* Admitted May 30, 1918, at 7 A.M. Condition poor; comatose, cold; respiration stertorous; pulse 100 and irregular. Resuscitation ward.

*Wound.*—Small, circular, through left temporal muscle at upper margin of pinna. X-ray—rifle bullet in *left* hemisphere close to entrance wound; deeply indriven bone.

*Neurological.*—Probable right hemiplegia. At 1 P.M. he was warm and pulse had improved; in view of the location of bullet operation was undertaken despite poor condition.

*Operation.*—May 30th, 2 P.M. (interval unknown). Novocaine and adrenalin. Triradiate incision and removal of block of bone. Clot extruded under pressure, carrying out the bullet. Very free bleeding not controlled by hot irrigation. Finger palpated a large cavity involving lateral ventricle. Gauze tampon carried into ventricle; scalp sutured.

*Post-operative Course.*—Died same day at 7.30 P.M.

*Autopsy.*—A large cavity in left parietal lobe containing clot and bone fragments; ventricle open, left choroid plexus apparently injured. Track continued through right parietal lobe to dura (Fig. 7). Anterior cerebral artery divided. No bone in right hemisphere.

*Comment.*—This is an example of the freakish things that the metallic fragment may do inside the cranium. Possibly the bullet rebounded from the right parietal bone along its track to midline, and was then carried toward the entrance wound by the hemorrhage.

### CLASSIFICATION OF FATALITIES

To sum up the causes of death in the seven fatalities following operation there were:

1. One death not attributable to the brain wound (Case VIII).
2. Two unavoidable deaths due to extensive brain injury (Cases XVIII and XIX).
3. One unavoidable death due to hemorrhage (Case XXI).
4. One unavoidable death due to sepsis in an incompletely cleaned cavity communicating with a nasal sinus (Case X).
5. One death from ventriculitis in which magnet extraction might have offered a chance (Case IX).
6. One death from sepsis which might possibly have been avoided by more complete operation (Case XX).

In addition, there was one septic brain fungus in Case XI, luckily not fatal, due to inefficient cleaning by the catheter technic, which would almost certainly have been avoided had finger palpation been used.

So far as is known, all of the thirteen evacuated cases are alive to-day, and their condition at last report is summed up in the following table:

## TOWNE AND GOETHALS

TABLE II  
*Tabulation of Late Results*

| Case | Last report | Head-ache   | Dizzi-ness | Epilepsy              | Other neurological signs                  | Occupation    |
|------|-------------|---|------------|-----------------------|---|---------------|
| 2    | 21 months   | +   | +          | o                     | Paraphasia. Paresis face. Mental changes. | Mill worker.  |
| 3    | 11 months   | +   | o          | o                     | Paresis, sensory loss arm                 | Working.      |
| 4    | 20 months   | +   | +          | o                     | o   | o             |
| 5    | 6 months    | Ambulatory, wounds healed. No further information.  |            |                       |   |               |
| 6    | 7 months    | +   | o          | o                     | o   | In hospital.  |
| 7    | 20 months   | +   | +          | o                     | Unilateral deafness                       | Working.      |
| 11   | 20 months   | o   | +          | Severe 12th month     | o   | o             |
| 12   | 20 months   | o   | o          | o                     | o   | Warehouseman. |
| 13   | 17½ months  | +   | o          | Jacksonian 10th month | Paraphasia                                | Mine worker.  |
| 14   | 20 months   | +   | +          | o                     | o   | Miner.        |
| 15   | 10 months   | Motor and sensory improvement 4 weeks, no medical report after. Discharged hospital 3d month; repatriated 10th month. |            |                       |   |               |
| 16   | 9 months    | ?   | ?          | o                     | Hemiplegia                                | o             |
| 17   | 19½ months  | +   | +          | Petit mal             | Hemianopsia                               | o             |

SUMMARY: Normal.....Cases 12, 14 = 2  
 Subnormal.....Cases 2, 3, 4, 6, 7 = 5  
 Pathological.....Cases 11, 13, 16, 17 = 4  
 Insufficient data.....Cases 5, 15 = 2

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Only two can be classed as normal individuals from the information at hand; both were working and had no discomforts of any moment, though one had a blind eye. Three of the subnormals were working and apparently not much handicapped. Only one of the pathological cases (XIII) was working, in spite of epilepsy; while the other three can never be self-supporting. The two cases unclassified because of lack of information would, at a guess, be normal (Case V) and pathological (Case XV).

## REVIEW OF LITERATURE

*Pathology.*—The existence of a cavity rather than a narrow track has been noted by many observers. Latarjet<sup>24</sup> says that the dural lesions are always less extensive than the brain lesions. Sencert<sup>33</sup> has seen brain cavities that would hold an egg progress to cure, and says that brain lesions become larger by the pressure of hemorrhage on the walls of the friable brain tissue. Schwartz and Mocquot,<sup>32</sup> speaking of metallic fragments lodged in the brain say, "There exists in these cases not only a track followed by these projectiles, but an actual *destructive cavity*." Archibald<sup>4</sup> puts it, "The area of destruction of brain substance is decidedly wider than the actual track of the projectile."

*Methods of Cleaning Brain Cavity.*—Among many different procedures that have been used separately or in combination, there are five which have numerous advocates: Finger palpation, curettage, catheter and forceps, extraction with magnet, and forceps extraction under visual control (radioscopic screen).

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*Extraction with the magnet or under the screen* are recognized as methods of value in recovering small and deeply placed metallic fragments. They require equipment which is not always available, and as they do not remove all the bone fragments and other foreign matter they must be combined with some other procedure if the track is to be properly cleaned. Rouvillois<sup>30</sup> claims for extraction under the screen that clot, damaged brain, and bone fragments precede the metal; he extracted thus 47 metallic fragments with 18 cures and 29 fatalities, but he does not give the incidence of encephalitis. One would suspect that the method could not be relied on to remove all bone fragments.

*Curettage* of the cavity in the brain has advocates whose results speak strongly for the method. Ehrenpreis<sup>14</sup> uses a small silver spoon with which he extracts very slowly and gently foreign bodies 6 or 7 cm. deep; he says that one recognizes without difficulty the difference in consistency between damaged and healthy brain. Henrard and Janssen<sup>20</sup> report four cured cases in which metallic fragments (one at level of the sella and 2 cm. behind the posterior clinoid processes) were extracted with the magnet. They curetted the track and closed the scalp temporarily over a tampon in the brain cavity. Tanton<sup>36</sup> curettes gently until white matter without clot begins to appear. Willems and Albert,<sup>40</sup> whose latest results (Willems<sup>39</sup>) are the best we have found in the literature, use the curette. Albert,<sup>2</sup> reporting the same series of cases in more detail, gives the technic as follows: Widen dural opening if necessary, remove bone fragments with a Kocher clamp, curette damaged brain and bone dust from the walls of the cavity and remove metallic fragment with magnet. Chauvin<sup>8</sup> says the walls of the curetted cavity ooze rather abundantly and persistently; and in this connection it is interesting to note that Henrard and Janssen tampon the cavity temporarily and do a secondary closure, and that Willems and Albert say that they tampon the cavity only when hemorrhage cannot be stopped by other means. There is a suggestion here that curettage may cause troublesome bleeding.

*Catheter palpation* with forceps extraction of metal and bone or with magnet extraction of the metal, as introduced by Cushing,<sup>10</sup> has been used by Ney,<sup>29</sup> Horrax,<sup>21</sup> Newton and Brown,<sup>28</sup> and Cutler,<sup>11</sup> all of whom found it satisfactory; and by Jefferson,<sup>22</sup> who says: "The evidence that was obtained from the catheter was . . . unreliable. It is so important to make sure that all indriven bone fragments have been removed, that the introduction of a finger into the brain wound can hardly be avoided." Newton and Brown say: "The practice of searching for bone fragments in the brain with the finger is one to be strongly condemned. Even when performed with great care it must result in increased damage to the brain. . . . In several cases in this series, one to one and a half hours were spent in the patient removal of fragments." That this painstaking cleansing by the catheter and forceps technic was not always complete is shown by their Case XVIII, in which autopsy showed unremoved bone fragments in a frontal lobe cavity. Horrax, using Cushing's technic, also

had failures; thus in Case XVII autopsy revealed bone fragments in an occipital lobe cavity; in Case XXIII there were unremoved bone fragments in a cerebellar cavity; and in Case XXIX a very large metallic fragment 2 inches from the dura was not detected at the first operation. Ney does not give case reports, but acknowledges that in wounds involving the ventricles the catheter tended to slide by the bone fragments in pockets of the walls of the cavity and enter the ventricle, "so it was mostly in these cases that the operation was not complete, in that some bone fragments would often be overlooked." Finally, in Cushing's<sup>9</sup> report there are examples of encephalitis attributable to incomplete removal of foreign bodies by the catheter technic, as in Cases LVI, LXIV and LXXIV. In mentioning these unsuccessful cases of the adherents of the catheter-forceps technic we have selected those instances in which it seems, as far as can be told from the details given, as though the finger technic might have been successfully applied.

*Finger Palpation.*—The literature indicates that by far the greater number of surgeons who have treated brain wounds advise this method, either alone or in combination with the magnet, curette or radioscopic screen. A few quotations from its stronger supporters will suffice. Leroy<sup>26</sup> says: "Digital exploration is indispensable for detecting the presence of bone fragments." Mathieu<sup>27</sup> says: "To detect bone fragments I do not hesitate to palpate the area of cerebral contusion with a gloved finger. It is a manœuvre that, better than any other, permits one to avoid overlooking a small fragment. In passing thus, exactly through the track, the surgeon is sure not to augment the injury to the nervous tissue; he remains in the contused zone always more extensive than the track itself. If there exist nervous symptoms from the anatomical lesion, he cannot hope to make them improve, it is true, but he does not augment them." Sencert<sup>28</sup> says: "When the cavity appears well cleaned and empty, I never fail to do a careful revision with the finger which discovers almost always one or more small bone fragments." Velter<sup>29</sup> says: "The intracerebral exploration should be made *with the finger*; the index, rather than the little finger, is introduced gently into the cavity; thus one easily detects the smallest bone fragments, and even if the finger is not in immediate contact with them, it perceives a special resistance which does not deceive an experienced observer; the metallic fragments are also easily found." Gray<sup>16</sup> says: "Only very rarely is further injury to the brain caused by this procedure." Others use the finger, but rather apologetically; thus Jefferson says it "can hardly be avoided," and Lemaitre<sup>25</sup> says: "Digital exploration should be feared because it is blind, but the finger detects foreign bodies deeply lodged in the cerebral tissue which a well guided forceps may thus seize." Among many others who practice finger palpation without any remarks on its advantages or disadvantages may be mentioned Abadie,<sup>1</sup> Bastianelli,<sup>6</sup> Burckhardt and Landois,<sup>7</sup> Delore and Arnaud,<sup>12</sup> Foisy,<sup>15</sup> Kaerger,<sup>23</sup> Sargent and Holmes,<sup>31</sup> and Schwartz and Mocquot.<sup>32</sup>

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### RESULTS

A study of the available reports shows that there are very few series of cases that can fairly be compared to ours. One must eliminate first of all those in which the scalp was not consistently closed, for they give no index of the value of the various methods of track cleaning. Secondly, cases not operated in forward hospitals during the first twenty-four hours after injury are of no use for comparison, for it has been shown that, paradoxical as it may seem, the cases done late at the Base frequently have a lower mortality rate than those operated in forward hospitals. The explanation is that the more serious brain injuries, as well as the less serious injuries with a fulminating infectious process, are eliminated by death and do not reach the Base hospitals; while in forward hospitals many of these less favorable cases are saved but more die, and mortality statistics necessarily rise in giving such risks a chance for life.

Taking only those series in which the scalp was closed after an early operation, one finds that there are still numerous sources of error. A forward hospital may take only "non-transportable" or the most seriously wounded, in which event a certain number of favorable brain wounds going back as walking cases are lost to its statistics. These favorable cases are often evacuated to the rear without operation, even if a forward hospital receives all head wounds from a given front. On the other hand, the mortality rates of an Evacuation Hospital which is well forward may be lowered because a Surgical Ambulance or a Mobile Hospital is working even further toward the lines and taking the most serious head cases. The question of judgment as to what are operable cases also plays a part, though it is noticeable that the tendency is to operate every head case that appears to offer the slightest hope of recovery unless, in so doing, the surgeon would jeopardize the chances of less seriously wounded men. Moreover, it makes a great difference whether the surgeon accepts all cases in rotation or selects his patients for operation. And finally, it is essential to know the late result, for a certain number of cases that appear to be cured when evacuated after ten to fourteen days do sometimes flare up with late abscess if all foreign bodies were not removed from the brain.

Of course, all these conditions for proper statistics cannot be met. But a good deal of interesting information can be drawn from the figures published. Taking the reports on brain wounds over which the scalp was not closed, we find that the early operative mortality is usually above 50 per cent.; and that this is not the whole story is shown by the figures of Sencert and Sieur.<sup>24</sup> They had an early mortality of 51.3 per cent., but on following up the evacuated, they found that, of 71 cases traced for over eleven months, 24 (presumably mostly brain wounds) had died. We have found only one series giving figures below 50 per cent.—that of Derache,<sup>19</sup> who operated 53 brain wounds, 15 of which died early, and 7 more in the following eight months, giving a mortality of 41.5 per cent. Several writers

give figures comparing their results before and after they adopted scalp closure. Gross and Houdard<sup>17, 18</sup> in 107 unsutured cases had an early operative mortality of 56 per cent.; while in a later series in which the scalp was sutured sixty-three times in 124 cases, their mortality was 38.7 per cent. Bárány's<sup>5</sup> figures are striking though incomplete. Without suture he lost 31 out of 39 brain wounds (79.5 per cent.). In his next 21 cases he closed the scalp unless the brain wound was complicated by eye or nasal sinus injuries; of 14 closed scalps only 4 died, and the mortality of the remaining 7 which were left open is not given.

Velter<sup>37</sup> gives a complete report of 27 cases operated in a forward hospital in 1915-1916. This series is apparently exactly comparable to ours except that his cases, although received early, were not always promptly operated. He used finger palpation and closed the wounds. The operative mortality is given as 33.3 per cent. Analysis of the cases shows, however, that he does not use quite the same classification of brain wounds, and that a revision of his statistics and inclusion of the late deaths would give a mortality in the vicinity of 50 per cent. Kaerger<sup>23</sup> reports 86 cases operated in a Feldlazarett with a mortality of 43 per cent. He used finger palpation and closed the wound. Cushing's<sup>9</sup> mortality in 133 cases was 41.35 per cent. Willems<sup>39</sup> had a 26.1 per cent. mortality in 46 operated cases. Among these were at least 11 cases in which an intact dura was opened and closed at operation; such a large proportion of this comparatively favorable type of brain wound may account to some extent for the very low figure. Cutler<sup>11</sup> operated 25 brain wounds with 6 deaths (24 per cent.), but "non-transportable" hospitals were working ahead of him, and some of his cases were under observation little over a week after operation.

The more one studies reports on brain wounds the more he is impressed with the fact that the figures are usually of little real value, and that the true criterion is whether fatal cases might have been saved by other methods. Unfortunately, very few reports give sufficient detail to form a basis for such judgment. If all series had been given in the same detail as Cushing's, for example, there would be an opportunity to form a much clearer opinion on the comparative values of the different methods of treatment.

#### THE ROUTINE TREATMENT

On notification of the admission of a head case, one of the members of the team saw him in the receiving ward as quickly as possible, made a rapid estimate of his general condition and neurological symptoms, and ordered him sent to the resuscitation ward, X-ray, or directly to the operating room. Unless obviously a subject for general anaesthesia the patient was given hot drinks. As soon as one of the team's two operating tables was free,  $\frac{1}{4}$  grain of morphia was administered if indicated, and the head was completely shaved and cleaned with soap, alcohol, and bichloride of mercury 1/1000. One member of the team dropped out of the operation in progress five or ten minutes before its completion and anæ-

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thetized the scalp of the next case. When general anæsthesia was required, novocaine and adrenalin were also used for hæmostasis. The operation proceeded in the following steps:

1. The damaged scalp and pericranium was excised; with fresh instruments the wound was extended in three directions, or a flap was turned down if the temporal or occipital muscles were involved. The dry wound was treated with tincture of iodine, and fresh towels or gauze were clamped over the reflected flaps leaving in the field only the area of fractured skull.

2. Usually a block of bone including the defect was excised by connecting several burr holes with a Montenovesi cutting forceps. Sometimes an extensive punched-out defect was merely enlarged with rongeur forceps. In any case less than 1.0 cm. of intact dura was exposed about the dural opening. Bone wax was used for hæmostasis.

3. The patient now coughed and strained. Pulped brain and clot which extruded immediately after removal of the bone block and at this stage were carefully removed with gauze sponges.

4. A 17 F. soft rubber catheter with an attached syringe removed all soft débris from the cavity by suction, beginning under the dura and progressing to the deepest portion. Then a few c.c. of hot normal saline solution were introduced and sucked out repeatedly until the solution returned clear.

5. A. If the information derived from X-ray, inspection, and catheter palpation indicated that the track in the brain was too small to permit introduction of a finger, the metal and bone fragments were removed as thoroughly as possible with delicate duck-billed forceps passed down the palpating catheter (Cushing's technic).

- B. If the defect in the dura was large enough, a finger was introduced very gently and each foreign body when palpated was seized and removed with the forceps.

- C. If the defect in the dura was too small to admit a finger, while all information pointed to a cavity in the brain large enough for finger exploration, the dura was incised to allow the finger to enter. When the cavity was clean it was again irrigated and sucked dry until hæmostasis was satisfactory. Bleeding pial or dural vessels were ligated with Cushing's silver clips.

6. The dura was sutured partially, or, if possible, completely, with fine chromicized catgut or silk.

7. The extra-dural wound was washed with ether and painted with tincture of iodine.

8. The scalp was closed with a few plain catgut stitches in the galea at the junction of the flaps, and with silkworm gut in the skin. A small gutta percha tissue wick was introduced to the bone if hæmostasis was doubtful.

Immediately after operation, if it was under local anæsthesia, the neurological findings were checked up. The patient was put up on a

back rest or high pillows. The wound was inspected daily; if it showed any tension or if headache was complained of a spinal puncture was done and repeated as often as indicated. Sutures and wick were usually removed in twenty-four or forty-eight hours.

After a review of the literature we would be inclined to modify this technic in one particular. When the track is too small for the finger, and the foreign bodies are not more than 6 or 7 cm. deep, it seems probable that a small flexible silver spoon would prove more satisfactory than the catheter and forceps. If a portable magnet were available, it would undoubtedly be of occasional service.

#### GENERAL CONSIDERATIONS

Throughout the war there was a tendency in some quarters to look on brain wounds as rather hopeless propositions, to be passed on to hospitals in the rear, or to be treated in "head centres" nearer the front. The feeling was that these casualties needed very specialized and expert care. One British army tried the concentration of head cases in a group of Clearing Stations in 1917, and the same idea was put into effect on a smaller scale in the American First Army in 1918. We happened to be able to observe part of each of these experiments, and received a strong impression that this was not the best way to deal with brain wounds, for it resulted in confusion in evacuation, decrease in ambulance efficiency, prolongation of the pre-operative interval, and early filling of beds with non-evacuable cases.

All of these disadvantages were avoidable by allowing each forward hospital to take care of brain wounds just as they came with the other casualties, and this was usually done with satisfactory results. Up to the publication of the catheter-forceps technic with its condemnation of finger exploration, it had been generally felt that a surgeon who was fitted to do major work in forward hospitals was capable of doing brain wounds, and the results had been quite good in spite of the inadequacy of the tools that were usually available. Cushing's paper was undoubtedly a blow to much of this work. A surgeon who had been rapidly cleaning brain cavities under finger control was now faced with the alternative of devoting "upward of two hours" to a case, or passing it on to the Base, unless he was willing to back his own experience and use his old methods. Those who have followed the Cushing technic have emphasized a fact that is very true—that it does require a great deal of experience, as well as a great deal of time. Cutler<sup>11</sup> says: "Unless a surgeon thoroughly familiar with this field of surgery is available in the most forward areas, it would seem to us advisable to transport such cases further back where men trained in this field may be found. . . . This may mean the necessity of very long transportation before operation. Even so, we think it would be safer than operation by untrained hands." Here we have the logical development of the tendency to make operations for brain wounds specialized and expert work, if a man trained in the catheter-

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forceps technic is not at hand, the case must undergo the risk of infection and travel back to such a man. This is against all the lessons of the war, which have brought out, above all else, the absolute necessity of providing the severely wounded with early and complete operation as the only safeguard against sepsis.

Operations on brain wounds do not deserve the reputation of being prolonged and difficult, or of requiring great experience. They are, as a matter of fact, quite easy provided one has the proper tools and knows how to use them. Abdominal wounds do best in the hands of a surgeon who has done much abdominal work. Excision of all the damaged tissues in a compound fracture of the femur so that the wound stays clean and can be secondarily sutured is an operation requiring a large amount of skill, patience, and experience. By comparison, a brain wound, especially if it can be quickly cleaned under finger control, is a very simple procedure. The type of surgeon who must handle most of the operating in forward areas—that is, the younger man, recently out of hospital—adapts himself rapidly to the unaccustomed work. We have seen surgeons with little or no previous experience in cranial work get excellent results immediately they had learned the few simple technical tricks of infiltrating the scalp, controlling hemorrhage from bone, dura or brain, using the palpating finger properly, and doing a plastic closure. But if one feels impelled to blindly clean a brain cavity without the aid of the finger, it is an entirely different story, for then a large amount of practice in the delicate technic of detecting fragments with the catheter and grasping them without injuring the adjacent healthy tissues is absolutely necessary. Nor, in our experience, does previous familiarity with civilian intracranial surgery prove of much help in this procedure. One of us had been trained in neurological surgery, but was quite unable to use the catheter technic satisfactorily; the other, with no previous experience, found that cleaning by the finger technic was an astonishingly rapid and easy operation.

### SUMMARY AND CONCLUSIONS

An unselected series of 28 brain wounds in a forward hospital was treated with the conception that the problem involved was the absolutely complete removal of contaminated damaged brain, blood-clot, hair, cloth, bone and metal, so that primary suture might result in clean healing. The method adopted was to suck and irrigate out the brain and clot, and then extract with fine forceps bone and metallic fragments detected by a gentle palpating finger, provided the cavity was sufficiently large to admit the finger. The size of the hole in the dura was not taken as an index, but was enlarged if necessary. In some cases this finger technic, always (with one exception) preferred if possible, was contraindicated by the small size of the track in brain substance, or by the awkward situation of wounds caused by missiles passing in via the deep nasal sinuses; in these instances cleaning was done as well as possible with catheter and forceps.

Of the 28 cases 8 were considered inoperable and died without intervention in a few hours; 20 were operated, and of these 7 died, giving a mortality of 35 per cent. More important than the mortality figure is a study of the cause of death in these 7 cases, which shows: 1 death from empyema with healing brain wound; 3 unavoidable deaths due to extensive brain injury or arterial hemorrhage; 1 unavoidable death due to sepsis, in which a deep cavity communicating with a nasal sinus could not be reached for proper cleaning; 1 death from streptococcus ventriculitis caused by a deep-lying minute metallic fragment which could probably not have been extracted even with a magnet, and 1 septic death from a wound involving cerebrum, lateral ventricle, and cerebellum in a case that should have been given the benefit of more extensive operation with removal of the metal through a counter opening. In short, there was no death from encephalitis when the metal and bone were within reach in a cavity large enough to admit the finger; and only two of the seven deaths could possibly have been avoided by the use of the magnet or by more extensive operative procedures.

A study of the 13 evacuated cases shows that 12 healed by first intention, and that the other developed a septic brain fungus, which was not fatal, after a prolonged attempt to clean a cavity by the catheter-forceps technic. In only one instance did routine post-operative examination show a slight and temporary increase in the signs of brain injury. Several cases are reported in which it seems highly improbable that the foreign bodies could have been removed without finger palpation. Later results in the 13 evacuated cases for periods of from six to twenty-one months after operation show that there were no late abscesses, that six patients were working, that major epilepsy developed twice, and that two only can be considered as not distinctly subnormal.

From these facts and from a study of the literature we would draw the following conclusions.

1. Entry of a foreign body into brain tissue causes irreparable damage to a more extensive area than that involved in the actual track of the foreign body, and this cavity is further broadened by hemorrhage; hence the size of the metallic fragment or of the dural aperture is not a true index to the wider area of damage represented by the brain cavity.

2. When such a cavity is not over 7 cm. deep and large enough to admit a finger, cleaning with forceps under careful finger control gives absolute insurance against sepsis, and only very rarely causes increased cerebral trauma which is slight and recoverable.

3. Cleaning of such a cavity by Cushing's method of catheter palpation is sometimes not complete and therefore does not always prevent sepsis; it necessitates a prolonged operation; and it is successful only in the hands of those who have had a large experience in its technic.

4. Brain wounds not suitable for finger palpation must be cleaned as well as possible by the catheter method, curettage, or magnet extraction, or a combination of these methods.

5. The tendency of the difficult catheter technic to make this a special

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field, which requires that the wounded undergo delay if a trained neurological surgeon is not at hand, is not for the best interests of the patient, who is put under increasing risk of encephalitis with every pre-operative hour.

6. Brain wounds, and especially those suitable for finger palpation, are easy to clean rapidly and successfully if a few proper instruments are available. Any surgeon fitted to do front-line work can quickly acquire the technic and do these cases in well under an hour; and, with experience in judging which casualties are inoperable, may well succeed in evacuating 75 per cent. or more of his operated cases.

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## CRANIO-CEREBRAL WOUNDS DUE TO PROJECTILES \*

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THERE were approximately 80 wounds in patients admitted to Base Hospital 61 diagnosed as head injuries. Of these, 60 involved the cranium and 20 the brain. Head injuries comprised about 5 per cent. of all our gunshot wounds. Unfortunately, accurate records of all our cases are not available. Record keeping was reduced to a minimum, and during rush periods these were very meagre indeed.

We have studied 40 cases of gunshot wounds involving the head. Eighteen were scalp wounds, and 22 were cranio-cerebral.

Of the scalp wounds little need be said except to emphasize that the greatest care should be taken in the diagnosis of these less serious lesions. It is best to explore these wounds when time will permit even in the presence of the negative routine X-ray finding.

In the cranio-cerebral group there were 22 gunshot fractures of the skull. From the clinical standpoint there were seven fractures involving the frontal bone, one the frontal and temporal, five the temporal alone, two the occipital, one the parietal alone, and one the temporal and parietal. In five the lines of fracture were not stated.

It is emphasized that the head injuries which were received at this Base were cases which had already received treatment at the front. They were post-operative cases or those in which operation had been deferred.

The question of what to do with retained intra-cranial foreign bodies presents an interesting phase of the subject. The following cases open this topic for discussion:

The first case was received in the first "convoy." He was admitted apparently *in extremis* and demonstrated the wonderful vitality which our soldiers have frequently shown. His case presented the following outstanding features: Gunshot wound of the temporo-parietal region; compound fracture of the skull; retained shell fragment; bacteræmia. Death. At autopsy, in addition, metastatic pulmonary abscesses.

Private W. S., aged twenty-two years, No. 2428567, Co. I, 325th Infantry, was wounded October 15, 1918. The following day a foreign body was localized by the X-ray, and a piece of bone removed. He was admitted to Base Hospital 61 October 27. Pus oozed from line of fracture. His condition was so poor that he was immediately placed on the critically-ill list. There was a smart hemorrhage from the scalp wound. The temporal artery was ligated in the ward.

Neurological examination by Lieut. Col. Somerville showed

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pupils were equal and reacted to light. There was weakness of both external recti. No optic neuritis. Disks clear but veins enlarged. No nystagmus. Tongue protruded straight. There was no disturbance of sensation. There was motor paralysis of both arms and lower extremities, not complete in right lower extremity and more marked on the right than on the left and in the muscles of the shoulder girdle. No astereognosis. All tendon reflexes exaggerated. Babinski, Oppenheim, and Chaddock signs positive right and left sides. Hoffman's sign was positive right and left. Slight spasticity of extremities. Abdominal reflexes absent. Cremasteric right slight, left absent. No aphasia. Slight hesitation and mental dullness.

The clinical symptoms indicated a lesion in both hemispheres due to abscess of the brain. After consultation the condition of the patient was considered too bad for operative interference. The patient died November 17, 1918.

At autopsy the subject was emaciated, general nutrition poor. Decubitus ulcers were found over sacral and scapula regions. There was a wound in the right temporo-parietal region. Both pupils were dilated, the left more than the right.

There was a suppurating wound located over the right temporo-parietal region. On the removal of the scalp, pus was found over the parietal and occipital regions. Upon the removal of the calvarium the meninges were found to be covered with pus, especially the left and right parietal regions. The exudate covered the pia along practically all the large vessels. There was an escape of much sero-purulent fluid from the spinal canal. The brain was sectioned horizontally just above the level of the corpus callosum. The missile had entered the skull in the right temporo-parietal region, traversed the right hemisphere, and was lodged in the left hemisphere just above the left lateral ventricle. The cavity surrounding the missile was 5 cm. long, 2 cm. wide, and 2 cm. deep. It was filled with thick yellow pus. The shell fragment was irregular in shape and measured 1 cm. long, 5 cm. wide, and 5 cm. thick (Fig. 1).

The left lung was firmly adherent at the apex. A few areas contained pus (metastatic abscesses). There were also metastatic abscesses in the lower margins of the left lobe surrounded by areas of consolidation.

The heart was normal. A few yellow plaques were found on the aorta at the ascending part of the arch and along the openings of the intercostal vessels.

The genito-urinary system, liver, spleen, thyroid, adrenals, and bones were normal.

Bacteriology. Heart's blood showed staphylococcus. A smear taken from the abscess of the brain showed streptococcus and many Gram-positive diplococci.

A second case of retained shell fragment shows the remarkable tolerance at times on the part of the brain to foreign bodies. The patient had meningeal symptoms which subsided following operation with recovery.

Corporal V. H., aged twenty-six years, Co. C, 30th Infantry, was first treated October 12, 1918, by Ambulance Co. No. 7. He was then removed to an evacuation hospital where X-ray revealed the presence of a foreign body in the occipital region of the brain. He was admitted to Base Hospital 61 October 15, 1918, and was in excellent condition. Eye grounds showed double choked disk, more marked on right. Later the left showed more swelling. Examination of spinal fluid showed a cell count of 160 per cm. There was rigidity of the neck for several days. The signs of meningitis disappeared and the patient began to improve. The bilateral choked disk persisted. Pupils normal. External ocular muscles normal. No paralysis of the face or extremities. Left-sided hemianopsia then developed. The abdominal reflexes were present and equal. There was no Babinski. The focal symptoms indicated a lesion in the right occipital region.

The temperature ranged from normal to 102.2 from October 15 to October 26, the pulse from 60 to 88, thereafter within normal limits. The foreign body was localized by the X-ray. Stereoscopic plates were taken.

On November 8, an exploration of the brain was made, but the foreign body was not recovered. The patient reacted well. The following day retinal hemorrhages were observed on and near the disk in both eyes. Choked disks were less marked on November 25. This patient was discharged and returned to the United States as a class "D" patient.

A case of shrapnel ball retained within the skull is of interest. The ball entered the right eye and fractured the orbital fossa. Private J. B., aged twenty-four years, Co. H, 23d Infantry, was wounded November 3 and admitted to Mobile Hospital No. 2. There a débridement of the wound of the scalp was done. Primary suture. The right eye was enucleated. He passed through Evacuation Hospital 10 where no entry was made on the field medical card. There was no record of any X-ray having been taken. The patient was admitted to Base Hospital 61 November 7, 1918. There was a contused wound of the left shoulder and scalp wound of the right parietal region. The right eye had been removed. Examination of the left eye showed mild catarrhal conjunctivitis, congestion of the head of the optic nerve and surrounding area, indicating a beginning neuroretinitis. He later developed a left-sided hemianopsia. No paralysis of face, arms, or legs.

He was X-rayed and we were somewhat surprised to learn of the presence of the foreign body. Convalescence was uneventful and he was returned to the United States.

Hernia of the brain may occur as a complication after the acute developments incident to gunshot fractures of the skull have subsided. We encountered one such case in a compound fracture of the frontal bone, also with retention of shell fragments.



FIG. 1.—Private W. S. Lateral view of the skull. Shows foreign body.



FIG. 2.—Same case. The white arrow points to the abscess cavity in the brain. The black arrow points to the foreign body.

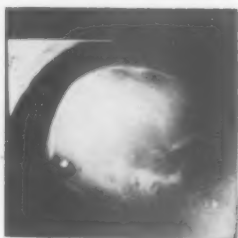


FIG. 3.—Lateral view of the skull. Corp. V. H. The white spot in the occipital region is the foreign body.



FIG. 4.—Private J. B. The white spot indicates a shrapnel ball.



FIG. 5.—Private L. A. Shows opening in the frontal bone, the seat of a compound fracture of the skull. The double subtemporal decompression and the foreign body are also shown. The white shadow indicates the latter. The shadows of decompressions overlap and lie above and in front of the shell fragment.



FIG. 6.—Pvt. M. P., age 25. 309 Inf.—Compound fracture of the frontal bone. Trephine opening in the skull above the safety pin (X-Ray taken with bandage on).



FIG. 7.—Pvt. A. B.—Compound depressed fracture of the frontal bone. Shows opening in the skull.



FIG. 8.—Pvt. R. J. R.—Compound fracture of the frontal bone. Note trephine opening and foreign body.

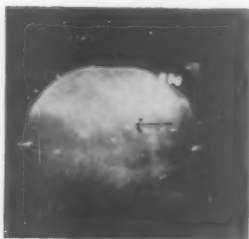


FIG. 9.—The same case, lateral view.



## CRANIO-CEREBRAL WOUNDS DUE TO PROJECTILES

Private L. A., Co. C, 320th Field Artillery, was admitted to Mobile Hospital 6 on October 18, 1918, from Field Hospital 328, in coma and much shock. The frontal bone had been fractured in the midline about 5 cm. above the nose. At operation the brain and dura were found injured. Spicules of bone had been driven into the frontal lobes of the brain. Three pieces were removed from a depth of 5 cm. and the wound was débrided. Neither dura nor scalp was completely closed.

Upon arrival at Base Hospital 61 eight days later, there was a fungous mass protruding through the skull a distance of  $1\frac{1}{2}$  cm. There was a loss of tissue about 2 cm. in diameter in the right frontal bone. There was a healed semilunar incision in this region 2 cm. above the right eyebrow. Marked aphasia and a partial right hemiplegia were present. The latter was more marked in the face and arms. The pupils were dilated and equal. Both eyes showed optic neuritis, left 4D and right 2D. Babinski sign was positive on the right side. Examination of eye grounds November 8, showed double choked disk, more marked on the left. Retinal hemorrhages on the left. A bilateral subtemporal decompression was performed on November 12. The hernia was removed and a celluloid plate was inserted into the defect. The skin was brought together under some tension. Improvement in aphasia and hemiplegia was progressive. The wound healed by primary union, leaving a small defect where the skin edges had separated. On November 19, the choking of the disks was less marked in both fundi, and on December 10, a sliding flap was made to cover the small defect in the skin of the forehead. This patient was returned to the United States. Upon discharge the wound was healed and the patient was in excellent condition.

Exophthalmos is an infrequent complication of fractures of the base. This was noticed in a compound depressed fracture of the mastoid portion of the temporal bone attended with an escape of brain tissue. The gunshot wound appeared below the right ear. There was no retention of the missile.

Private A. R., Co. F, 61st Infantry, was admitted to Evacuation Hospital 6 October 17, 1918, where his wound was débrided and depressed fragments of bone removed. The patient was in shock and showed some rigidity of the neck. There developed marked exophthalmos of the right eye. Brain tissue and spinal fluid were discharged from the external auditory meatus. When brought to Base Hospital 61 on October 24, seven days later, he was in much pain. There was rigidity of the neck, a marked exophthalmos, and a discharge of cerebrospinal fluid from the right ear. On November 3, under treatment, much improvement was noted. Exophthalmos diminished, but there was persistent rigidity of the neck. No paralysis of face or extremities. The knee-jerks were both very active, left more than right. Left ankle clonus present, no Babinski. Patient continued to improve. On December 9, complete atrophy of

the right optic nerve was recorded, no vision. The patient was returned to the United States.

Aphasia is commonly seen in civil practice, and has been commonly encountered by us in war fractures of the skull.

Private A. B., Co. M, 77th Division, aged twenty-five years, sustained multiple gunshot wounds. He passed through Field Hospital 238 where he was dressed, and Evacuation Hospital 14 on October 15, 1918, where a compound depressed fracture of the frontal bone was diagnosed. At the operation, the depressed fragments of bone and two small foreign bodies were removed.

Upon admission to Base Hospital 61 October 26, 1918, a wound in the frontal region showed a free discharge of pus. There was no pathological condition of the fundi noted. The patient stated that following the injury he could not talk, but he knew what he wished to say (motor aphasia). On November 2, he showed no symptoms of aphasia. There was a slight weakness in the lower muscles of the right side of the face. The patient soon recovered sufficiently to be returned to the United States.

Infection, focal symptoms, and hernia of the brain do not necessarily follow a compound fracture of the skull even in those cases in which a foreign body remains imbedded in the brain. The following case showed a smooth rapid recovery, almost without interest:

Private R. J. R., Co. G, 26th Infantry, was wounded October 4, 1918. He was admitted to a mobile hospital the same day with a depressed fracture of the frontal region of the skull. The scalp wound was excised, the opening in the skull enlarged and depressed fragments removed. No foreign body was found. The dura was closed. He was subsequently admitted to Base Hospital 61 October 9, 1918. The wound was found clean and the sutures were removed. The X-ray demonstrated the opening in the frontal region and a small foreign body. Lateral view shows a foreign body 1 by  $\frac{1}{2}$  cm. in the temporal region. He was finally discharged and returned to the United States.

The writer wishes to make, in addition, the following points:

1. The incidence of various lesions encountered under "head injuries in battle casualties."
2. The mortality of cranio-cerebral wounds.
3. Surgical treatment of these lesions.

In Cushing's series of compound fractures of the skull he noted a mortality of 9 per cent. in those cases in which there was contusion of the brain, with or without depression of the skull and with intact dura. Depressed fractures with punctured dura he usually found attended with neurologic symptoms. The mortality was 11 per cent. In those cases presenting severe cerebral contusion due to in-driven fragments of bone occasionally showing extrusion of the brain, fungus, or encephalitis, the mortality was 24 per cent. In the penetrating cerebral wounds with

## CRANIO-CEREBRAL WOUNDS DUE TO PROJECTILES

marked contusion along the tract, with lodgment of the projectile and bone fragments, at times hernia of the brain, lesions which frequently lead to early compression or late abscess, he found the mortality was 36.5 per cent. Penetrating wounds of the ventricles attended with hemorrhage and infection of these structures are the most serious wounds which may be encountered. Penetration may be due either to bone fragments or projectile. If due to projectiles the mortality is 100 per cent.; if due to bone fragments, 43.5 per cent. In another series with involvement of the orbital, nasal, and auropetrosal areas, meningitis is frequent and the mortality 73.3 per cent. In the case of through-and-through cranial wounds the mortality is 80 per cent. In wounds with massive comminution of the skull the mortality is 50 per cent.

During the late war a serious effort has been made to reduce the commonly accepted mortality of 50 per cent. for cases of compound fractures of the skull as seen in civil life. In this Cushing has been successful through the development of a standardized procedure and technic. Thus, in his first series of 44 cases, the mortality for the whole was 54.5 per cent. In a second series of a like number of cases he reduced the mortality to 40.9 per cent., and in a third series of cases to 28.8 per cent.

The improvement in mortality in no wise indicates that in the third series of cases were the lesions selected or of a less serious nature. On the contrary, more unpromising injuries were treated as technic developed.

Cushing's routine pre-operative features consist of preliminary neurologic study of all cases, stereoscopic X-ray negatives, shaving of the entire scalp, and the use of local anæsthesia. All serious cases should be dressed in the operating room rather than in wards—no doubt all these factors contribute to a successful outcome in serious cases.

The main features of Cushing's procedure are as follows:

1. The removal *en bloc* of the area of cranial penetration.
2. In the detection of in-driven fragments of bone by means of rubber catheter palpation rather than by digital or other instrumental exploration.
3. In the suction method of removal of disorganized brain tissue, the retention of which pulped or devitalized tissue in the tract favors infection.
4. Cushing considers dichloramine-T particularly suitable for infection in brain tissue.

Cushing gives preference to the radial or tripod incisions and believes in the closure of wounds.

In the matter of primary wound closure, considerable discussion has been evoked. Thus, Moulouguet and Legrain emphatically declare it to be dangerous, maintaining that a wide excision of injured tissues of the brain (the single desideratum of success) is not practical. Gross and Houdart, on the other hand, believe that to attain success in primary wound closure, it is sufficient to wash the cerebral tissues with warm serum and to lightly curette clots, bone splinters, or foreign bodies. Tanton, who is also a great partisan of primary wound closure, states

that complete disinfection of cranio-cerebral wounds is easy to obtain. Willems has more recently formulated the same opinion.

Moulonguet and Legrain believe the infectious action of a projectile is not negligible. They offer an additional theoretical objection to primary closure. They maintain that the pulsations of the brain in the case of open wounds eliminate secretions, bruised and soiled tissues, and minute bone splinters which have been overlooked at the primary operation.

As regards the treatment of deeply implanted foreign bodies in the brain, Cushing believes that they can best be removed by the magnet. The ideal treatment consists in the removal of projectiles at the primary operation, otherwise the operation must be regarded as incomplete. There is far greater likelihood of the development of subsequent abscess than if the removal of the missile had been accomplished, but the forcing of an operation to the point of increasing the damage already done to the brain by penetration should never be done.

Even good-sized foreign bodies may be retained without provoking symptoms, but, even so, late abscess is not infrequent, and the best advice is to extract the missile, if it can be accomplished without increasing the damage already done.

Moulonguet and Legrain state that the extraction of foreign bodies by the electro-magnet, apart from being useless in the case of non-magnetic bodies, necessitates a complicated apparatus.

In the matter of drainage of the brain, there is little discussion. This should not be done with tubes for fear of causing ulceration. Lumbar puncture should be performed in cases of meningitis and hypertension.

Primary cranioplasty for loss of bone substance is not advised by Cushing except when the defects are large in the scalp or when the ventricle has been opened. Secondary plastics, however, are frequently in order, as illustrated by a case in the preceding paper in which a celluloid plate was inserted after amputation of the hernia and bilateral decompression.

Wounds of the skull repair spontaneously, but in most instances it is not bony. Mayet studied a series of 21 cases of defects in the skull a year after injury and there was newly-made bone in no instance. Occasionally, however, very small fragments of periosteum may regenerate bone substance and help to repair the loss, especially in small wounds.

Cranioplastic operations have made much progress during the war, but they must not be attempted too soon. First ascertain that there is no dormant infection or foreign body in the wound.

Repairs may be made with non-living substances, such as celluloid, ivory, metal, lime paste or calcinated bone, or with living grafts of cartilage or bone and periosteum. The latter may be taken from other bones of the body or from the neighborhood of the wound. In the latter case it may be an osteo-periosteal flap, in which case there is greater assurance of life.

In the case of non-living substances, the hole is simply corked, but in the

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case of the living grafts, on the whole to be advocated, the discrepancy is filled with a repairing substance. It may be feared that disturbances due to compression of the brain may result, and to obviate this danger a prophylactic decompression may be performed as in the case alluded to.

Statistics published by Villandre show the following results:

In those cases in which lime paste was used, 50 per cent. were favorable; in cartilaginous cranioplasty, 96.8 per cent.; in the case of grafts taken from the skull, 100 per cent.

## FOREIGN BODIES OF DENTAL ORIGIN IN A BRONCHUS PULMONARY COMPLICATION\*

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FOREIGN bodies of various kinds are undoubtedly lodged in the bronchi more frequently than they are recognized. Weist reported 1000 cases; 103 (10.3 per cent.) only were from the literature, 897 (89.7 per cent.) were unpublished cases collected by Weist by personal communications. It would seem possible that a correspondingly large proportion of cases of dental origin remains unpublished.

Foreign bodies of dental origin include teeth, dentures, instruments, and other material used in dental operations. Aspiration of infected blood or sputum is probably a more frequent source of infection than foreign bodies. The occurrence of such infection is obviously greatly more difficult to prove, but the frequency of gross mouth infection in patients subjected to dental operations needs hardly be mentioned.

There have been at the Mayo Clinic during the past four years 7 cases of pulmonary suppuration following dental operations or trauma. In 2 cases the tooth was spontaneously expelled; in one it was discharged through a thoracotomy wound, and in one it was found at postmortem. In the other cases no foreign body was found, but it is quite probable that they were also cases of infection from inhalation.

I observed 6 of the 7 cases and have collected 45 proved cases from the literature. These 52 cases form the basis of this report.

### FOREIGN BODIES IN THE 52 CASES

|                             |    |
|-----------------------------|----|
| Teeth .....                 | 37 |
| Artificial teeth .....      | 4  |
| Dentures .....              | 2  |
| Root canal broach .....     | 2  |
| Dental burr .....           | 3  |
| Allen's dental cement ..... | 1  |
| Plaster of Paris .....      | 1  |
| Hard rubber from gag .....  | 1  |
| Blade of forceps .....      | 1  |

The foreign body was lodged in the right bronchus in 21 cases, in the left bronchus in 19, in both sides in 1, and in the trachea in 1; the location was not stated in 10. The bodies were most frequently in the right lower lobe.

In 26 cases the accident occurred during extraction under general anæ-

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\* Presented before the Minnesota State Dental Association, Minneapolis, March, 1920.

## FOREIGN BODIES OF DENTAL ORIGIN IN A BRONCHUS

thetia, in 12 under nitrous oxide, in 11 under ether, and in 3 under chloroform. In 3 cases false teeth were inspired; in 4 cases the foreign body was inspired during dental operations without anæsthesia.

The literature contains more or less fragmentary reports of other similar cases (Carpenter, Ricketts, Stokes, McCrae).

*Symptoms and Signs.*—The symptoms may be divided into those which are manifest immediately following the inhalation of the foreign body, and those which arise from its prolonged presence in the respiratory tract. The most constant and characteristic immediate symptom is cough of varying intensity and persistence; associated symptoms are dyspnoea, cyanosis, wheezy respiration, pain in the chest, and nausea. In the 52 cases cough, more or less violent and spasmodic, was an immediate symptom in 27, pain or soreness in the chest in 13, and dyspnoea in 10. In one instance cough started after twenty-four hours, in another after four days. In 12 there was no cough. In 4 cases dyspnoea of a varying grade was the presenting symptom. In one only was there a sensation of a foreign body in a bronchus. It is noteworthy that in 7 cases (13.4 per cent.) there were no symptoms whatsoever. In 16 of the series there were no serious pulmonary infections; in the remaining 36 there was evidence of pulmonary suppuration of varying grade. For convenience, in the further discussion the cases will be grouped on this basis.

In the 16 uncomplicated cases the accident occurred during general anæsthesia in 4, and during alcoholic intoxication in 1. No anæsthesia was used in 2, and no statement was made as to anæsthesia in 9. Symptoms were marked in 7, and not mentioned in 9. A diagnosis was made by the X-ray in 5; in 1 the plate showed only pleural thickening. In 8 there was no mention of an X-ray examination. With two exceptions the length of time the foreign body was present in the bronchus was short. In one a tooth was coughed up after three years; in another plaster-of-Paris fragments had been present for five years without symptoms other than a persistent spasmodic cough.

The foreign material was spontaneously expelled in 4 cases on the third day, the fifth day, during the third month, and three years after the accident, respectively. Early bronchoscopic removal was effected in 10. Two patients died, one from typhoid fever ten days after bronchoscopy, and one from tuberculosis following temporary recovery from an unsuccessful thoracotomy.

*Complications.*—This group comprised 36 cases. In 22 the accident occurred during the extraction of teeth under general anæsthesia; in 2 others in which it followed extraction the anæsthesia was not mentioned; in 2 loose artificial teeth or dentures were inhaled; in 1 a tooth was inhaled during a general anæsthetic for an abdominal operation; in 1 pulmonary infection followed a kick in the face by a horse, resulting in the loss of several teeth.

*Immediate Symptoms.*—In this group cough of varying severity asso-

ciated with other symptoms, such as dyspnoea, cyanosis, and pain in the chest, was manifest in 11. In 7 cases cough was the only symptom; in 3 there was no cough; in 10 there were no immediate symptoms, or they were so mild and transitory as to be practically negligible.

A latent symptomless period was present in 15. The length of the latent period was two weeks or under in 3, between two weeks and two months in 7, more than two months and under one year in 2, two years in 1, and eleven and one-half years in 1. There was no latent period in 13. The records in the remaining cases were indefinite on this point.

*Late Symptoms.*—Cough, usually with purulent sputum, was present in 29 cases, hæmoptysis in 8, and pain in the chest in 11. The onset of late symptoms was gradual and without any intervening symptomless period in at least 13. The relation was not stated in 8. X-ray reports were mentioned in 16. The plates showed the foreign body in only 4 cases, an artificial tooth with a piece of denture in 1, a tooth in 2, and a dental burr in 1. Abscess was shown in 5 cases; one case diagnosed tuberculosis proved on postmortem to be bronchiectasis. A fluoroscopic examination revealed limitation of movement of the diaphragm in one case; negative X-ray findings for foreign body were reported in 12 cases.

It would appear on first thought that a diagnosis should be established by the fact that a foreign body passed down the pharynx. In the present series of cases the patient was usually unconscious at the time of the accident. In one case (Carpenter's) the patient believed that he had swallowed, not inspired, a denture with four teeth; its presence in the lung was never suspected and was only proved at postmortem after thirteen years. In one case only (Hubbard's) did the patient insist that the foreign body was in the lung in spite of negative X-ray and other findings.

In cases without immediate severe symptoms the operator may believe or fervently hope that the foreign body passed down the œsophagus instead of the trachea. In one case (Jarvis's) the dentist obviously had such hopes, in spite of the fact that the patient, a physician, had paroxysmal cough and other characteristic symptoms of foreign body in a bronchus immediately on awakening from anæsthesia. When the patient asked to see the tooth the dentist explained that it had broken and was thrown away. Three months later the physician coughed up the tooth.

In cases of multiple extraction, as in 22 instances in this series, a tooth or stump of a tooth is easily lost without being missed.

*Treatment.*—Bronchoscopy was done for the removal of foreign bodies in 5 cases, in 3 of which the X-ray showed the foreign body. In the fourth case a second X-ray plate, taken after a positive clinical diagnosis of foreign body had been made, showed the foreign body. In the fifth case no X-ray was taken. In 2 of these cases the foreign body was removed at the first attempt; in 1 two unsuccessful high bronchoscopies were followed by a third successful low bronchoscopy after tracheotomy; in a fourth the bronchoscopies failed. Doctor Jackson had seen this case

## FOREIGN BODIES OF DENTAL ORIGIN IN A BRONCHUS

and believed the foreign body to be beyond reach of the bronchoscope. In still another case in which bronchoscopy failed, a first-stage operation was done for drainage and the patient died before the second-stage operation had been undertaken. Thoracotomy was done in 15 cases; in 2 of these the lung was resected. In the remaining 13 cases the operation was done for drainage of the suppurating process.

*Results.*—Fourteen of the 36 patients with complications died; 16 made a complete recovery, and the result in the remaining 6 cases is not definitely stated. There were seven deaths in the 24 cases occurring since 1900.

Seven of the 14 patients who spontaneously expelled the foreign body recovered, and 3 died; the ultimate result was not stated or was uncertain in 4. In 3 cases an abscess requiring drainage developed after the foreign body had been expelled; in one case the foreign body was discharged through the drainage wound, and in one case the tooth was expelled after two and one-half years. Seven months later an abscess developed, and after two months the patient died. In 15 cases in which thoracotomy was performed 2 were followed by resection of the lung; both patients died; 1 died of exhaustion, and 1 of pulmonary embolus before the second-stage drainage operation. One died while being chloroformed for drainage operation. One improved so markedly following the preliminary rib-resection that the second-stage operation was not done. In the remaining 11 cases, 1 patient died, 1 was greatly improved, and 9 made a complete recovery.

### POSTMORTEM FINDINGS IN 9 FATAL CASES

1. Bilateral bronchiectasis, empyema, tooth in bronchus.
2. Pulmonary embolism.
3. Large empyema fistula in lung, denture in pleural cavity.
4. Abscess, ulcerated bronchus, tuberculosis.
5. Abscess, tooth in bronchus.
6. Abscess, empyema, tooth in bronchus.
7. Massive gangrene of entire lung, tooth obstructing bronchus.
8. Bilateral lower lobe bronchiectasis, tuberculosis, tooth in bronchus.
9. Bronchiectasis, pericarditis, tooth in bronchus.

### DISCUSSION

In this series of cases the relationship between multiple extractions of teeth under general anæsthesia and pulmonary complication is striking. Multiple extractions under general anæsthesia were performed in 22 instances. Aspirative infection as a cause for pulmonary suppuration may probably be assumed to be sufficiently evident in the cases in which the tooth was later expelled, or in which an impacted tooth was found in the midst of a suppurative or gangrenous process in the lung. Perhaps the most striking evidence of all is shown in the case of Israël, in which a

tooth was found in an actinomycotic abscess of the lung. That aspiration of infected material from the mouth independent of teeth is a large factor in the causation of pulmonary infection cannot be so clearly demonstrated in the individual case, but much evidence has accumulated indicating that aspiration of infected material is one of the most common causes of abscess, gangrene, and bronchiectasis. As early as 1877, Schüller found that the introduction of clean foods into bronchi of rabbits through tracheal wounds is practically harmless, while the introduction of the same foods mixed with bacteria and filth results in a fatal pneumonia. Lung abscess following tonsillectomy has been reported frequently (Manges, Tewksbury, Bassin, Frank, and others). Külbs found bad teeth and tartar (Zahnstein) in a large proportion of cases of lung abscess in which he operated. In a series of 56 cases of pulmonary suppuration at the Mayo Clinic in which operation was done, aspiration of an infection was probable in 25 per cent.; the etiology was questionable in another 25 per cent., but it is probable that a large proportion of these were cases of aspirative infection.

The importance of early recognition of a foreign body in a bronchus is emphasized by the fact that in this series there was no mortality in the cases in which it was expelled or removed early by bronchoscopy. All the fatalities, with the exception of one death following lung resection, were in cases in which the foreign body had been present for a long period.

Positive diagnosis may be made by means of the history, the X-ray, or by bronchoscopy. It is important to remember, however, that each and all of these may be negative in the presence of a foreign body, as in 12 cases in this series. Symptoms and signs are suggestive, but in themselves are rarely conclusive. In many cases they have led to an erroneous diagnosis of tuberculosis.

The history of the case is of first importance. If the operator knows that a tooth has passed down the pharynx, and the patient immediately develops symptoms of bronchial irritation, the diagnosis is obvious. Even in the absence of symptoms, it should be assumed that the foreign body passed down the trachea rather than the œsophagus until the contrary is proved. No marked immediate symptoms occurred in 9 of the 22 cases and there was a later symptomless period in 16 of 35 cases. In one case it was of thirteen years' duration. The profession has been slow to recognize that a symptomless period does not constitute proof of absence of a foreign body. Jackson writes on this point: "Practitioners are heedless of and even scoff at the patient's suspicions that a long previously aspirated (or swallowed)<sup>1</sup> foreign body is the cause of present symptoms."

Examination by the X-ray is indispensable, and a positive plate establishes the diagnosis both as to the presence and the location of the foreign body. A negative X-ray, however, is not conclusive and in the presence of a diffuse shadow from pulmonary suppuration is of doubtful value. In

<sup>1</sup> Inserted by the author.

## FOREIGN BODIES OF DENTAL ORIGIN IN A BRONCHUS

the 16 uncomplicated cases in this series, the X-ray was positive in 6 of the 7 cases examined, but in the group with complications it failed to show the foreign body in 12 of the 16 cases examined.

In early uncomplicated cases bronchoscopy in skillful hands is the best method of diagnosis and of removal. The indications for bronchoscopy for a foreign body as enunciated by Chevalier Jackson are as follows:

1. The appearance in the röntgenogram of a foreign body or of any suspicious shadow.
2. Cases in which a clear history is given of the patient's having choked on a foreign body, and in which the foreign body was not afterwards found.
3. Cases in which there are signs of stenosis of the trachea or the bronchus.
4. In any case suspected of bronchiectasis.
5. In the absence of any history of a foreign body, the patient giving symptoms of pulmonary tuberculosis, without the finding of bacilli in the sputum, and especially if the physical signs are at the right base, and above all, if there are also physical signs of pleural effusion.
6. In case of doubt, bronchoscopy should be done.

Jackson recognizes no absolute contra-indications to bronchoscopy.

### TREATMENT

Expectant treatment is employed in the hope that the foreign body may be expelled spontaneously; bronchoscopy and thoracotomy are the alternatives, after the foreign body has been recognized.

The question of the likelihood of the expulsion of the foreign body is often raised in the consideration of the advisability of bronchoscopy. In this series the tooth was expelled in only 3 of 13 cases before the onset of pulmonary suppuration. The tooth was expelled in 13 of 33 cases after suppuration had developed. Six of these patients recovered, but thoracotomy had to be done in 4 instances. Three patients who received no further treatment died. Jackson's attitude toward the question of spontaneous expulsion is as follows: "We do full justice to our patients when we tell them that while the foreign body may be coughed up, it is very dangerous to wait; and further that the difficulty of removal increases with each hour the body is allowed to remain."

If the foreign body has not been recognized, however, or the patient has been treated expectantly until suppuration has set in, the results following bronchoscopy are not so favorable. In 5 such cases in this series in which bronchoscopy was done the foreign body was removed in only one. It may be impossible to locate the tooth and it must be seen in order to be removed. Furthermore, its removal in the presence of pulmonary suppuration becomes only an incident. The important consideration in such cases is the suppurating focus. For this complication thoracotomy for drainage has given the best results. If the focus is in the form of a localized solitary abscess, a drainage operation is the

operation of choice. If the cavity is multilocular or if there is a bronchiectasis, any form of treatment is likely to yield a high morbidity and mortality. Massive gangrene is uniformly and quickly fatal.

The table of postmortem findings is uncontrovertible evidence of the possible etiologic relationship of foreign body aspiration to abscess, gangrene, and bronchiectasis.

With regard to details of dental operative technic for prevention of accidental aspiration of foreign bodies, Doctor Gardner of the Mayo Clinic in a personal communication expressed himself as follows:

"The patient should be watched quite as carefully with a local anæsthetic as with a general. The use of gauze sponges in no way interferes with the work of the operator; it prevents the inhalation of a foreign body during operation and cares also for the hemorrhage. Furthermore, the dentist may, by careful examination of the teeth before operation, ascertain if the work might displace pieces of tartar, fillings, or even the teeth themselves during a general anæsthetic. The condition of the patient undergoing any operation often requires the use of a gag during an ether anæsthetic, and the anæsthetist should know the condition of the patient's teeth before the anæsthetic is started, since such an instrument often displaces from a tooth foreign bodies which might be inhaled."

#### SUMMARY

1. Aspiration infection of the lungs is most common in operations about the mouth following general anæsthesia.
2. Symptoms may be immediate and continuous or there may be an intervening symptomless period of months or years. There may be no immediate symptoms.
3. The most constant and characteristic immediate symptoms are cough, dyspnoea, wheezy respiration, and pain in the chest. The late symptoms in varying number and degree are those of pulmonary suppuration.
4. Late symptoms of foreign-body infection often simulate phthisis, and that is the diagnosis often made.
5. Positive diagnosis rests essentially on history-taking, X-ray, and bronchoscopy. The history may be that of having "swallowed" the foreign body.
6. Bronchoscopy for diagnosis is indicated in any early doubtful case.
7. Spontaneous expulsion of small irregular foreign bodies of high specific gravity, especially teeth, is always doubtful. Spontaneous expulsion often occurs only after an abscess has formed.
8. Bronchoscopy is the only treatment to be considered in early uncomplicated cases. In cases in which there is suppuration, thoracotomy for drainage gives the best results.
9. In fatal cases death is usually due to abscess, bronchiectasis, or gangrene of the lung, any of which may be complicated by empyema.
10. Tuberculosis may coexist with a suppurative process.

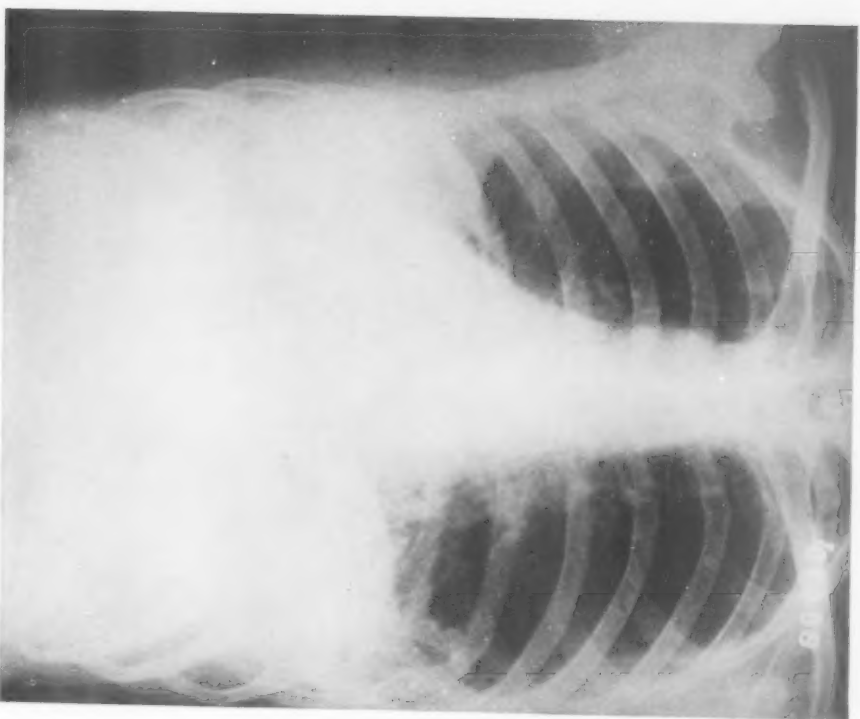


FIG. 1.—(10958) Roentgenogram made eight months after teeth extraction.

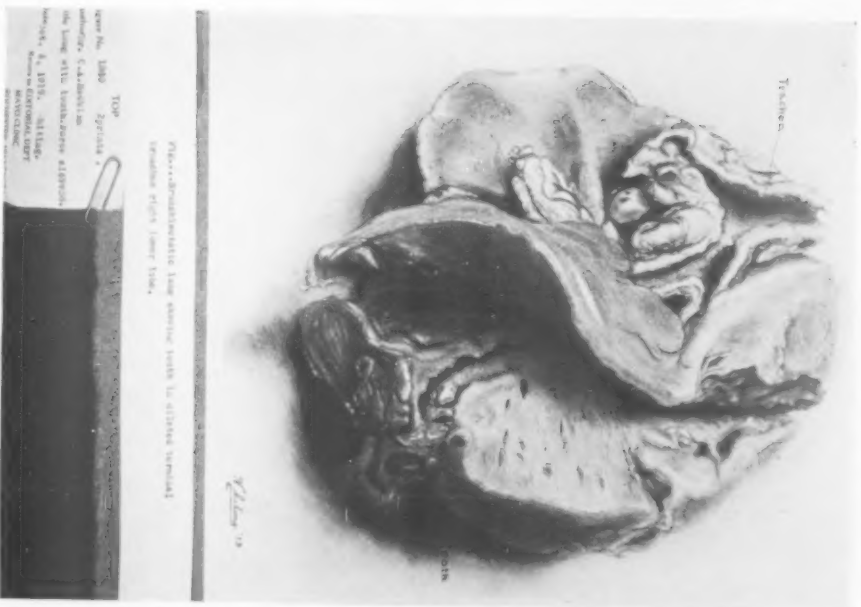


FIG. 2.—(10958) Drawing of bronchiectatic lung, showing tooth in dilated terminal bronchus of right lower lobe.

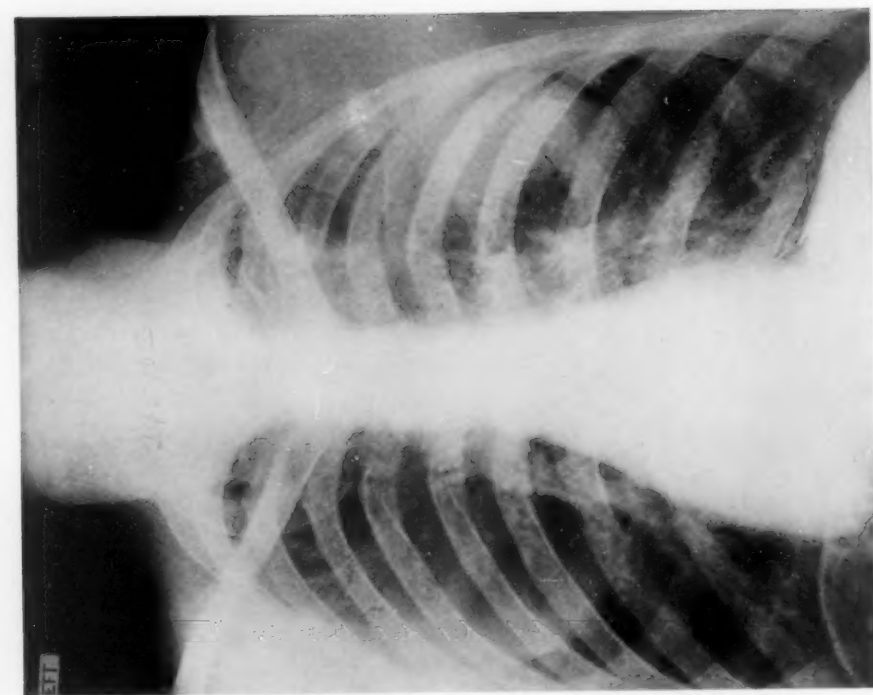


FIG. 3.—(240703) Röntgenogram made before operation about two and one-half months after teeth extraction. Note the fluid level



FIG. 4.—(240703) Röntgenogram made eighteen days after operation.

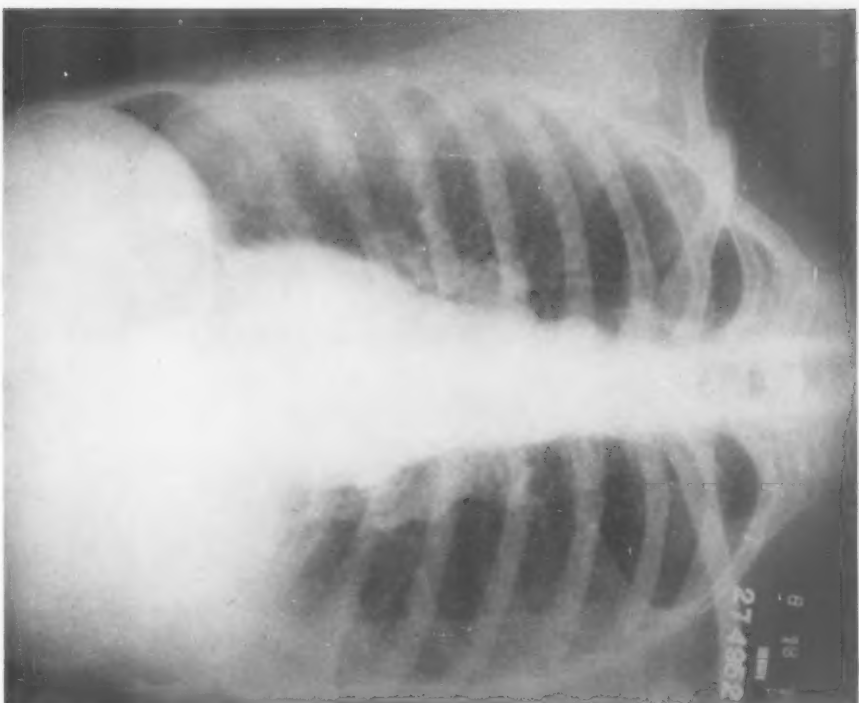


FIG. 5.—(281586) Röntgenogram made nine days before operation.

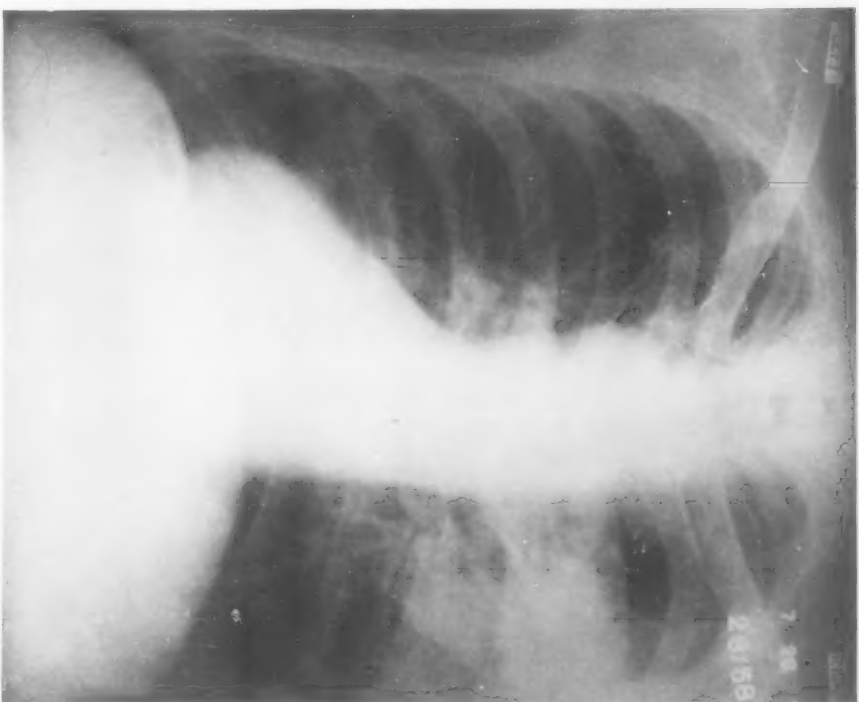


FIG. 6.—(174733) Röntgenogram made two days before expelling tooth.

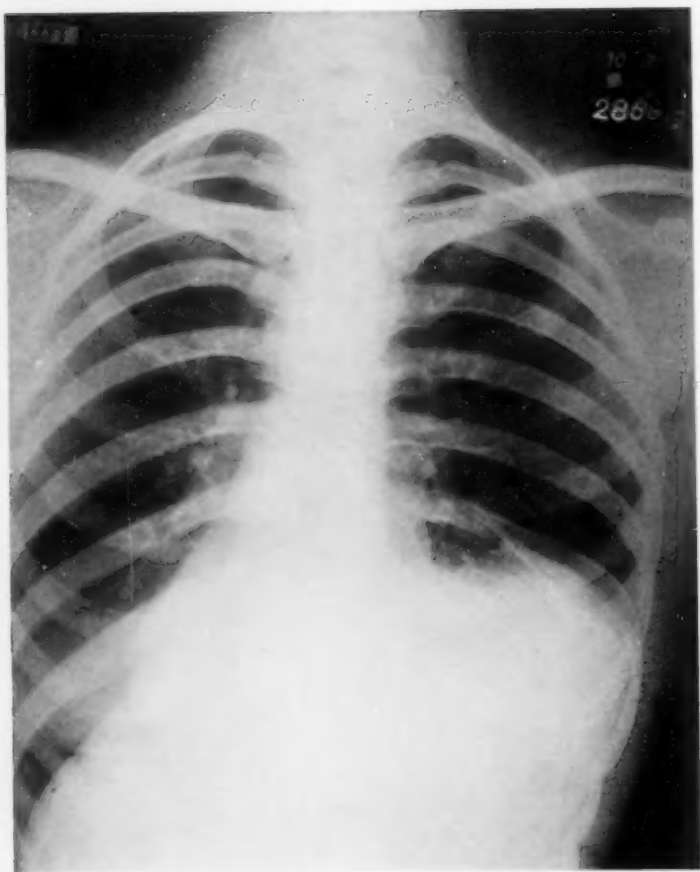


FIG. 7.—(286912) Röntgenogram made about one and one-half years after patient expelled two pieces of teeth and silver filling.

## FOREIGN BODIES OF DENTAL ORIGIN IN A BRONCHUS

CASE I (169958).—E. R. F., aged thirty-four years, an anæmic, emaciated woman, came to the clinic August 21, 1916, complaining of cough with sputum, pain in the back, fever, weakness, and loss of weight.

The illness began in January, 1915, following teeth extraction under general anæsthesia. The patient began to cough immediately on awakening from the anæsthesia and the cough had persisted. Pulmonary tuberculosis was diagnosed for which she was treated for a number of months. September, 1915, an X-ray was taken and a tooth was revealed in the lower part of the right lung. Three attempts were made to remove the tooth by bronchoscopy but all failed. Thoracotomy was then done, but the tooth was not found.

When the patient came to the clinic her cough was very severe and persistent, preventing sleep. Pain in the back with fever had started six weeks before. She had lost 30 pounds in weight. The sputum was foetid, greenish, and amounted to upward of a pint in twenty-four hours.

At the time of examination the hæmoglobin was 76 per cent., the leucocyte count 17,600, the systolic blood-pressure 117, the diastolic 60, the pulse 96, and the temperature 100.5°. Resonance was impaired and breath sounds were diminished at both bases. There was a scar of thoracotomy below the angle of the right scapula. The skiagram showed shadows at both bases which were believed to be due to the thickened pleura at the right and a small amount of fluid at the left base. The appearance of the right lower lobe suggested tuberculosis. The clinical diagnosis was old abscess of the right lung, and left pleurisy with effusion. August 25th a bronchoscopic examination was made. The tooth was not found, but much pus was seen coming from the right bronchus. Thoracentesis of the left pleural cavity yielded pus. August 28th a first-stage operation was done for drainage of the abscess. The patient died, however, before the second-stage drainage operation could be performed.

Necropsy showed a bilateral bronchiectasis and left empyema. The broken tooth, surrounded by an abscess, was found lying within 2.5 cm. of the lower surface near the lateral aspect of the lung (Figs. 1 and 2).

CASE II (216141).—J. R., a man aged sixty-six years, came for examination December 8, 1917. This patient appeared older than his years, probably due, in part, to exposure and to alcoholic excess. His illness began in October, 1917, after teeth extraction under ether anæsthesia. A number of teeth were broken off, and considerable bleeding followed for two weeks. Immediately after the operation the patient developed a constant dull pain in the right lower chest anteriorly. These symptoms persisted for two weeks, when he suddenly vomited a pint of pus; coughing and a large amount of purulent sputum persisted, especially during the month before examination, and kept him awake a great deal at night.

Examination of the chest showed an area of flatness in the right axilla. The hæmoglobin was 50 per cent., and leucocyte count 13,000. The systolic blood-pressure was 140, the diastolic 66, the pulse 84,

and the temperature normal. Repeated sputum examinations were negative for tuberculosis bacilli. The skiagram showed dense infiltration in the upper portion of the right lobe with cavitation. The patient was a poor surgical risk and he was kept under observation in the hope that there might be some improvement. His symptoms instead of subsiding, however, became more aggravated. Four weeks later the skiagram showed marked extension of the purulent process; operation was therefore advised. The patient was transfused once before the operation by the sodium citrate method, receiving one-half litre of blood. A two-stage drainage operation under local anaesthesia was performed because of the absence of pleural adhesions. An abscess cavity the size of a large orange and containing a mass of gangrenous lung tissue was found. The patient's convalescence was rapid; four months after the operation he had gained 50 pounds in weight. He was dismissed from the clinic with a small sinus. Five months later a portion of a tooth was found in the dressings. The sinus then rapidly closed. In September, 1919, the wound was solid and there were no symptoms referable to the old pulmonary lesions.

CASE III (235649).—Mrs. N. F., aged thirty-nine years, presented herself at the Mayo Clinic June 18, 1918, complaining of persistent cough with purulent sputum and occasional hæmoptysis. Her illness began in August, 1917, following teeth extraction under ether. The day following the operation she coughed up 4 or 5 ounces of dark, clotted blood having a very foul odor. She continued to cough and to raise large amounts of pus and blood. She also developed pleurisy with effusion, for which a thoracotomy was performed in September, 1917, and a secondary operation for drainage in November.

The patient coughed frequently during the examination, raising a bloody purulent sputum having a very foul odor. There was dullness in the left axilla, moist râles, and tubular breathing toward the apex. The hæmoglobin was 80 per cent. and the leucocyte count was 9400. The systolic blood-pressure was 126, the diastolic 70, the pulse and temperature normal. There was distinct clubbing of the fingers. The sputum was repeatedly examined for tuberculous bacilli, but none were found. The skiagram showed infiltration of the lower left lobe of the lung, and a diagnosis of probable abscess was made. An exploratory aspiration was performed in the region of the thoracotomy incision. The first operation was interrupted by an epileptiform seizure followed by lapse of consciousness for about five minutes. Six days later a tubular cavity was opened and drained. The patient left the hospital two weeks later; the wound drained for some weeks and then closed. There have been no further symptoms.

CASE IV (240703).—J. K. S., a man aged forty-five years, came for examination August 1, 1918. He appeared to be very sick and complained of cough with much foul sputum. He had had several teeth extracted in May, 1918. Two weeks later he began to cough, raising

## FOREIGN BODIES OF DENTAL ORIGIN IN A BRONCHUS

foul-smelling sputum, sometimes 24 ounces each day. Slight swelling of the legs had been noted.

The physical examination disclosed marked loss of weight, foul breath, systolic blood-pressure 110, diastolic 60, pulse 80, and temperature 98°. The right chest wall was markedly retracted and there was an area of dullness about the level of the second and third ribs anteriorly. Breath sounds in this region were intensified. No tuberculosis bacilli were found in the sputum. The skiagram showed marked infiltration in the upper right lobe which was diagnosed abscess with cavitation. The fluoroscopic examination revealed a fluid level with distinct splashing.

A two-stage operation was performed for drainage of the abscess, which was found to lie about in the midaxillary line. The abscess contained little pus, but some very foul-smelling necrotic tissue was removed. The convalescence was slow, although progressive, and the patient left the hospital with a bronchial fistula. January 19, 1919, the patient reported by letter that he had gained 38 pounds in weight, that the fistula had closed, and that there were no symptoms referable to his former illness (Figs. 3 and 4).

CASE V (281586).—J. A. C., a rather frail looking man, aged sixty-three years, came to the clinic July 23, 1919, complaining of cough with sputum, weakness, and loss of weight. His illness began in October, 1918, when he was kicked in the face by a horse. The kick was a glancing blow, breaking the bridge of the nose and knocking out several teeth. He was knocked unconscious by the blow. There was some cough immediately on recovering consciousness, and the patient believes that he must have swallowed a great deal of blood, because his stools were black following the accident. Eight weeks later a corrective operation under cocaine was done on his nose. He then had a mild attack of pneumonia; he was in the hospital for four weeks, and had several attacks of hæmoptysis. One month after recovering from pneumonia he developed severe pain in the right chest with fever running up to 103°. Twenty-four hours after the onset of this illness the "abscess broke," and a pint of pus was coughed up. There has since been a persistent cough with sputum, amounting to about a teacupful in twenty-four hours, progressive weakness, and a weight loss of between 20 and 30 pounds (Fig. 5).

Slight dullness was found at the right apex anteriorly, with marked amphoric breathing. The respiratory excursion at the right apex was lagging. Many teeth were missing, and those remaining showed marked pyorrhœa and some were carious. The hæmoglobin was 58 per cent., and the leucocyte count 16,000. The systolic blood-pressure was 134, the diastolic 84, the pulse 88, and the temperature 101°. Sputum examination for tuberculosis bacilli and elastic tissue was negative. The skiagram showed a large abscess in the upper lobe of the right lung. The clinical diagnosis was probable aspiration abscess. A two-stage drainage operation was performed as pleural adhesions could not be definitely made out. A deeply situated abscess about 3 inches in diameter was opened and drained. The

convalescence was uneventful and the patient went home three and one-half weeks following operation in good general condition. He had no cough or sputum at this time and had gained 15 pounds in weight.

CASE VI (274952).—Mrs. J. S., a thin, rather frail looking woman, aged thirty years, presented herself June 12, 1919, complaining of headache and pain in the abdomen which began following childbirth January, 1919. In May, 1919, the patient was given ether for teeth extraction. She began to cough immediately on awakening from the anaesthesia. The cough, paroxysmal in character and worse at night, continued and was accompanied by more or less pain in the lower substernal region. The expectoration was mostly foamy mucus and moderate in amount. Perspiration was profuse at night; vomiting was frequent.

The patient was a poorly developed woman with marked evidence of loss of weight. At the time of examination the hæmoglobin was 64 per cent., and the leucocyte count 9000. All the teeth were missing. There were râles and increased breath sounds at the right apex. The right base was dull to percussion. The sputum was negative for tuberculosis bacilli. The X-ray examination showed pleural thickening with probable fluid at the right base. The diagnosis was that of general debility with probable slight right pleural effusion. The question of the presence of a foreign body was raised, but there was no definite evidence, and the patient was discharged without surgical treatment. June 15, 1919, during a very severe paroxysm of coughing she expelled a tooth. The cough and expectoration immediately became somewhat less, but at the last report, August 7, 1919, she still had pain in her back and some cough (Fig. 6).

CASE VII (286912).—Mrs. A. K., aged thirty-three years, presented herself September 1, 1919, complaining of a cough with purulent sputum, weakness, and loss of weight. The onset of her illness dated back nineteen months, following extraction of many teeth under general anaesthesia. She began to cough immediately on awakening from the anaesthesia; the cough persisted. Six weeks after the teeth extraction she coughed up two pieces of tooth, and twelve weeks later a silver filling. The cough, however, continued; the sputum was foul and amounted to a cupful in twenty-four hours. She had pain in the right chest, night sweats, and occasional hæmoptysis. The symptoms instead of subsiding after the foreign body was expelled became progressively worse.

At the time of examination the patient was sitting with a basin before her, coughing more or less continuously, and raising very foul purulent sputum. The systolic blood-pressure was 100, the diastolic 60, the pulse 72, the hæmoglobin 80 per cent., and the leucocyte count 5000. The sputum examination was negative for tuberculosis bacilli. The skiagram showed a questionable shadow just behind the heart at the cardiophrenic angle. Because of the incessant cough and large amount of sputum, it seemed advisable to do an exploratory operation notwithstanding the meagre X-ray and physical find-



| Author                 | Age Sex | Foreign body                             | Location                                   | Nature of accident   | Anæsthesia       | Immediate symptoms   | Late symptoms   |
|------------------------|---------|--|--|--|------------------|--|---|
| Abercrombie...         | ? F     | Artificial tooth                         | Not stated                                 | Aspiration of loose artificial tooth   | Not stated       | Cough, dyspnoea, pain in chest   | Cough with purulent sputum in chest   |
| Carpenter.....         | 35 M    | Four false teeth on silver clamp         | Right pleural cavity                       | Swallowed tooth in a fit of coughing. Took catharsis. Incident then forgotten  | None             | None   | First 11½ years; of shortness of breath in chest; cough in chest  |
| Kappesser.....         | 20 F    | Molar tooth                              | Left bronchus                              | Teeth extracted  | N <sub>2</sub> O | Spasmodic cough. Pain in chest   | Cough; purulent sputum; moptysis; pain distant breathing  |
| Chambers.....          | 35 F    | Tooth                                    | Left bronchus                              | Thirteen teeth extracted   | N <sub>2</sub> O | Fainted on recovering from anesthesia. Cough dyspnoea, nausea, prostration   | Dyspnoea; nausea; cough; sputum; solidation in lung   |
| Israel.....            | 26 M    | Fragment of tooth                        | Left lower lobe                            | Not stated   | None             | Not stated   | Pain in left chest; sinuses and retractions; marked emaciation; violent cough; hæmoptysis; feebleness in right chest  |
| Wigg.....              | 30 F    | Tooth                                    | Right bronchus                             | Tooth slipped from forceps during extraction of teeth                          | Ether            | Slight cough   | Cough; fetid sputum in right base   |
| Verco.....             | 27 F    | Tooth                                    | Right bronchus                             | Teeth extracted  | N <sub>2</sub> O | Severe cough, profuse perspiration, fever, pain in chest. Tasted and smelled tooth                                 | Cough; fetid sputum in right base   |
| Verco.....             | 39 F    | Tooth                                    | Right bronchus                             | Teeth extracted  | N <sub>2</sub> O | Severe cough with sputum having odor and taste of bad teeth  | Cough; fetid sputum in right base   |
| MacCormac....          | 24 F    | Blade of forceps                         | Right bronchus                             | Teeth extracted; forceps broke   | Chloroform       | Violent spasmodic cough, extreme cyanosis, severe pain in chest  | Cough; dyspnoea; hæmoptysis; sputum; signs of a lung abscess  |
| Himmelsbach...         | 21 F    | Tooth                                    | Left bronchus                              | Five teeth extracted   | N <sub>2</sub> O | Periodic dyspnoea, violent cough and wheezing  | Cough; sputum, of bronchitis  |
| Warrack.....           | 26 F    | Tooth                                    | Left bronchus                              | Teeth extracted  | N <sub>2</sub> O | Extreme cyanosis, tightness of throat, dyspnoea, hard, dry, paroxysmal cough, wheezy respiration. No breath sounds | Hectic temperature; sive breath, brassy sputum, cough   |
| Arnold.....            | 23 F    | Artificial tooth with plate              | Lower right bronchus                       | While eating   | None             | Extreme dyspnoea; spasmodic cough  | Slight cough, muco-purulent râles, right chest  |
| Godlee.....            | 47 M    | Molar tooth                              | Lower right bronchus                       | Not stated   | None             | After 10 minutes extreme dyspnoea. Slight pain in right chest  | Spasmodic cough; hæmoptysis; sputum; signs of a lung abscess  |
| Strange.....           | 23 F    | Part of tooth                            | Right bronchus                             | Unsuccessful attempt at teeth extraction. Part of tooth loosened               | Not stated       | Not stated   | Symptoms of gangrene  |
| Dickson.....           | 28 M    | Stump of upper molar                     | Left bronchus                              | Twelve stumps of teeth extracted   | N <sub>2</sub> O | Cough with slight uneasiness behind the sternum; no pain   | Influenza with slight purulent sputum; 3 weeks of dry cough   |
| Kulbs.....             | 48 M    | Piece of carious tooth                   | Right upper lobe                           | Not stated   | Not stated       | Not stated   | Four hundred cavitomies containing signs of cavity; cough; loss of vocal sputum 14th day  |
| Monro.....             | 10 M    | Tooth                                    | Left bronchus                              | Loose tooth probably aspirated. Operation for tuberculosis of knee under ether | Ether            | None   | Cough and fever; loss of vocal sputum 14th day  |
| Smith.....             | ? M     | Burr                                     | Left upper lobe                            | Drilling back upper molar  | No               | None; went to board meeting  | None  |
| Freidberg.....         | 24 F    | Tooth                                    | Right bronchus                             | Extraction of 10 teeth   | Ether            | Cough; pain in right side  | Increased cough; pain in chest;   |
| Thomson.....           | 10 F    | Tooth                                    | Left bronchus                              | Inhaled from towel on waking up after anesthesia                               | N <sub>2</sub> O | Wheezy respiration. Physical examination after several days; very little air entering lung                         | After a month symptoms of a lung abscess  |
| Morrison.....          | 36 F    | Tooth                                    | Left bronchus                              | Six to 8 teeth extracted   | Chloroform       | Dyspnoea; tightness in chest; said stump of tooth had gone down in throat  | After 3 weeks, cough; hæmoptysis; profuse sputum; loss of weight and strength   |
| Brauch.....            | 22 F    | Premolar tooth                           | Not stated                                 | Teeth extracted  | Chloroform       | Slight dyspnoea  | Lung abscess  |
| Getchell.....          | 24 F    | Root of tooth                            | Lesions in both bases, most marked on left | Extraction of several teeth  | Ether            | Indefinite left pleurisy?  | Pain; cough; four tent fever; hæmoptysis  |
| Getchell.....          | 16 F    | Tooth                                    | Right bronchus                             | Six teeth extracted  | N <sub>2</sub> O | "Ailing"   | After 3½ months, cough; hæmoptysis; in bed; breath offensive; chronic cough;  |
| Hubbard.....           | .....   | Tooth                                    | .....                                      | Dental operation   | .....            | Not stated   | Chronic cough;  |
| Hubbard.....           | 34 F    | Disc of Allen's dental cement, 7 x 9 mm. | Left lower lobe of bronchus                | Extraction of 22 teeth   | Ether            | Cough almost continuous during waking hours  | Fever; cough; sputum; emaciation; diagnosed chronic cough;  |
| Hubbard.....           | .....   | Tooth                                    | .....                                      | Dental operation   | .....            | Not stated   | Chronic cough;  |
| Robinson (Mayo Clinic) | 34 F    | Tooth                                    | Right lower lobe                           | Teeth extracted  | Ether            | Cough; sputum; pain in back  | Cough; pint foul sputum in chest;   |
| Barker.....            | ? F     | Tooth                                    | Right bronchus                             | Not stated   | Not stated       | Not stated   | Not stated  |
| Pirie.....             | ? M     | Tooth                                    | .....                                      | Extraction of several teeth  | Not stated       | Not stated   | Bloody expectoration; left side; duration; constant cough; sputum; loss of weight   |
| Forbes.....            | 39 F    | Tooth and bone                           | Left bronchus                              | Several teeth extracted  | General          | None for several weeks   | Constant cough; sputum; loss of weight  |
| Hedblom (Mayo Clinic)  | 66 M    | Tooth                                    | Right upper lobe of bronchus               | Many teeth extracted   | Ether            | Dull pain in lower right chest; bled considerably; cough; sputum with foul odor                                    | Dull pain; cough; 4 weeks after extraction; sudden onset of cough; moist râles; tuberculous clubbing of fingers; chronic cough; cough; foul sputum of right chest |
| Hedblom (Mayo Clinic)  | 39 F    | Tooth ?                                  | Left lower lobe                            | Teeth extracted  | Ether            | Cough  | Moist râles; tuberculous clubbing of fingers; chronic cough; cough; foul sputum of right chest  |
| Hedblom (Mayo Clinic)  | 45 M    | Tooth ?                                  | Not stated                                 | 26 teeth extracted   | Ether            | None   | Cough; foul sputum of right chest   |
| Hedblom (Mayo Clinic)  | 63 M    | Tooth ?                                  | Not stated                                 | Kicked by horse  | Cocain           | Cough for 24 hours; tarry stools   | Eight weeks after extraction; monia, then hæmoptysis; sputum, pain in lower lung cut off; cough and purulent sputum each day                                      |
| Hedblom (Mayo Clinic)  | 33 F    | Two teeth and silver filling             | Right lower lobe                           | Teeth extracted  | Ether            | Cough  | Cough and purulent sputum each day  |

| Author                 | Age Sex | Foreign body                      | Location  | Nature of accident                    | Anæsthesia           | Immediate symptoms   |
|------------------------|---------|-----------------------------------|---|---------------------------------------|----------------------|--|
| Medicolegal reports... | .....   | Porcelain tooth                   | Right bronchus  | Not stated                            | Not stated           | Not stated   |
| Jackson.....           | 13 ?    | Molar tooth                       | Right inferior bronchus   | Not stated                            | Not stated           | Not stated   |
| Jackson.....           | 14 ?    | Molar tooth                       | Right upper bronchus  | Not stated                            | Not stated           | Not stated   |
| Jackson.....           | 39 M    | Root canal broach                 | Small posterior branch of a larger posterior root branch of inferior bronchus | Not stated                            | Not stated           | Not stated   |
| Shurly.....            | .....   | Tooth ?                           | Not stated  | Teeth extracted                       | N <sub>2</sub> O     | Cough  |
| Shurly.....            | ? F     | Hard rubber from dental mouth gag | Not stated  | Teeth extracted                       | N <sub>2</sub> O     | Cough, odor of rubber; lower lung cut off                                  |
| Shurly.....            | 49 M    | Dental burr                       | Lower left bronchus   | Drilling of teeth                     | No                   | Not stated   |
| Munger.....            | .....   | Dental burr                       | Trachea   | Not stated                            | Not stated           | Not stated   |
| Freidberg.....         | 35 M    | Three teeth bridge                | Left bronchus   | Aspiration during intoxication sleep  | Alcohol intoxication | Cough, moderate soreness on pressure                                       |
| Freidberg.....         | 46 M    | Dental broach                     | Left main bronchus  | Dental operation                      | Not stated           | Paroxysmal cough   |
| Lynch.....             | ? F     | Plaster of Paris                  | Both lungs  | Making cast of mouth                  | None                 | Persistent, spasmodic cough  |
| Mayer.....             | .....   | Gold crown of wisdom tooth        | Not stated  | Not stated                            | Not stated           | Not stated   |
| Fowler.....            | .....   | Teeth                             | Lower left bronchus   | Not stated                            | Not stated           | Not stated   |
| Jarvis.....            | 50 M    | Tooth and crown                   | Left bronchus   | Extraction of lower left wisdom tooth | N <sub>2</sub> O     | Dyspnoea, cough; tracheitis; fever; râles; slight sputum                   |
| Murphy.....            | 30 F    | Porcelain tooth                   | Right lower bronchus  | Tooth slipped from dental forceps     | Not stated           | Not stated   |
| Hedblom (Mayo Clinic)  | 30 F    | Teeth                             | Right bronchus ?  | Extraction several teeth              | Ether                | Paroxysmal cough; nasal pain on right; frequent vomiting; increased breath |

# CASES WITH COMPLICATIONS

| Chief symptoms   | X-ray  | Latent period             | Spontaneous expulsion                             | Treatment   | Results   | Postmortem   | Remarks   |
|--|--|---------------------------|---|---|---|--|---|
| Purulent sputum; pain  | None   | Not stated                | Two years seven months after accident             | Not stated  | Seven months later recurrence of symptoms suggesting an abscess; died 13 years after accident |  | Died 9 months after expelling tooth.  |
| Occasional attacks of breath; fever; pain in right chest; dullness in right chest                    | None   | 11 1/2 years              | No  | Symptomatic   |   | Fistula of lung opened into large empyema cavity containing pus. Lung collapsed. Denture with 4 teeth found in the pleural cavity. Left lung tubercular.   |   |
| Purulent sputum; fever; hæmoptysis; nausea; vomiting   | None   | None                      | One month after accident                          | Symptomatic   | One month after accident coughed up half a molar tooth; died the same day                     | Ulcerating right bronchus apparently the site of tooth. Abscess at the base of lung; probably tuberculosis.  | All symptoms disappeared in five weeks  |
| Nausea; cough; mucopurulent sputum; fever; signs of consolidation in left chest                      | None   | None                      | Six days after accident                           | None  | Complete recovery   |  |   |
| Chest; purulent sputum; retraction of chest wall; maciation. Pus containing rosettes                 | None   | None                      | None  | No surgical treatment   | Died one and one-half years after onset of symptoms   | Cavitation in left lung; fragment of tooth in pleural cavity   | Patient, a hostler, drank out of same trough as his horse.  |
| Purulent sputum; fever; pain in chest; right base  | Negative   | Fourth day                | None  | Thoracotomy performed to facilitate expulsion   | Died three and one-half weeks after accident  | Large empty empyema; small abscess in middle lower lobe; bicuspid tightly impacted.  | About 12 weeks after the accident coughed up the tooth.   |
| Purulent sputum; fever; dullness in chest  | None   | None                      | Twelve weeks after accident                       | Symptomatic   | No record   |  | Abscess burst 2 months after tooth extraction.  |
| Purulent sputum; fever   | None   | Two months                | Three weeks after accident                        | Symptomatic   | Died from suffocation following sudden bursting of abscess                                    |  | Great difficulty experienced in getting hold on blade.  |
| Chest; pain in right chest. Respiratory stridor, râles   | None   | None                      | No  | Tracheotomy, instrumental removal   | Complete recovery   |  | Coughed up tooth with cotton pack in cavity; immediate relief of symptoms.                              |
| Hæmoptysis. Signs of tuberculosis  | Not stated   | None                      | Four and one-half months after accident           | None  | Complete recovery   |  |   |
| Temperatures, 13th day offensive, brown, foul smelling   | Not stated   | None                      | No  | None  | Died 16 days after accident   | Complete obstruction of left main bronchus. Whole lung gangrenous; crowned bicuspid tooth wedged into bronchus; ball valve obstruction.                    | One of the early instances of X-ray localization.   |
| Mucoid sputum, transillumination of right chest  | Tooth localized by triangulation   | Two months                | Two months after accident                         | Thoracotomy. Operation twice interrupted on account of hemorrhage. Foreign body loosened  | Foreign body coughed up after operation. Complete recovery                                    |  |   |
| Purulent sputum; sudden pain; emaciation of abscess  | None   | None                      | No  | Drainage of abscess; no foreign body found  | Died 14 months after accident   | Advanced bilateral tuberculosis; cavity of right apex, tuberculosis of cæcum; bilateral lower lobe; bronchiectasis; tooth in lower right lobe of bronchus. |   |
| Gangrenous abscess   | Not stated   | Not stated                | No  | Thoracotomy for drainage of abscess; tooth not found  | Complete recovery.  |  | Diagnosed tuberculosis by several consultants.  |
| Severe cough and purulent sputum after a few days; transient aphonia after dry pleurisy, persistent  | None   | Three weeks               | Thirteen and one-half months after accident       | Symptomatic   | Sudden recurring hæmoptysis; coughed up tooth; recovery.                                      |  |   |
| Expectoration of foul sputum; elastic tissue fibres; cavity; duration of symptoms months             | Not stated   | Not stated                | No  | Thoracotomy for drainage of lung abscess  | Marked improvement; small fistula 2 months after operation.                                   |  |   |
| Fever on 4th day, râles; vocal fremitus; offensive   | Not stated   | No                        | No  | Symptomatic   | Died 16th day after accident  | Entire lung gangrenous.  |   |
| Burr in left upper lobe  | Yes  | No                        | No  | Four bronchoscopies failed. Partial pneumonectomy   | Patient died from operation; burr obtained  |  | Dr. Jackson thought it too far out for bronchoscopy.  |
| Purulent sputum; fever; chest; loss of weight  | Tooth  | Not stated                | No  | Foreign body removed by upper bronchoscopy under ether 9 weeks after accident   | Expectoration and cough continued for several months; further history unknown.                |  | Small abscess cavity behind tooth; pus released on pulling tooth from bronchus.                         |
| Months fever and other signs of abscess  | Tooth; limited movement of diaphragm. Later X-ray showed opacity of lung         | Two months                | No  | Two unsuccessful bronchoscopies before abscess formation; tracheotomy; lower bronchoscopy; foreign body removed 2 months after accident | Complete recovery   |  |   |
| Cough; fever; hæmoptysis; fetid sputum; loss of strength   | Negative   | Three weeks               | No  | Thoracotomy; resection of large part of lower lobe of lung  | Died of pericarditis on 28th day after operation  | Pericarditis; tooth stump impacted in bronchus; missed in resection by 3/4 inch  | Diagnosis of bronchiectasis from foreign body was made only after 2 years of symptoms.                  |
| Not stated   | Not stated   | Two years                 | Yes   | None  | Much bloody, foul sputum; serious collapse but ultimate recovery.                             |  | Recurrence of abscess?  |
| Purulent sputum; intermittent hæmoptysis; pneumonia  | Not stated   | Two weeks                 | Two weeks after accident                          | Drainage of lung abscess  | Recovery  |  |   |
| Months "Typhoid bronchitis" bed from 3 to 4 weeks; offensive; cough; foul sputum                     | Negative   | Three and one-half months | One year after accident                           | Postural treatment; much improvement  | Not known.  |  | Not very ill at any time.   |
| Purulent sputum  |  |                           |   | None  | Spontaneous recovery after several years  |  |   |
| Purulent sputum; emaciation; tuberculosis  | Negative   | None                      | No  | Bronchoscopic; removal 7th month  | Perfect recovery; gain in weight 34 pounds.   |  |   |
| Purulent sputum  |  |                           |   | None  | Spontaneous recovery after several months.  |  |   |
| Foul sputum in 24 hours; chest; fever; emaciation  | Tuberculosis of right base? No foreign body                                      | Eight months              | No  | Bronchoscopy; pus in right bronchus; aspirating left pleural cavity pus; first stage operation, drainage, abscess of left lung          | Died shortly after thoracotomy operation  | Bilateral bronchiectasis; left empyema; tooth in lower lobe of right lung  | Tooth within 2.5 cm. of inferior surface of lower lobe.   |
| Not stated   | Not stated   | Not stated                | No  | Thoracotomy for removal of foreign body   | Died while being chloroformed for operation   |  | Gangrene and empyema; postmortem (?)  |
| Expectoration; chills; pain; duration, 6 days  | Negative   | Not stated                | No  | Thoracotomy for drainage  | Complete recovery   |  | X-ray showed fluid level in abscess cavity.   |
| Cough; profuse purulent sputum; loss of weight 68 pounds   | First plate negative for tooth; abscess of left upper lobe. Later X-ray positive | Few weeks                 | Piece of bone and tooth                           | Eleven bronchoscopies; suction to abscess cavity; injection of argyrol  | Not stated  |  | Foreign body not suspected until patient coughed up piece of bone 5 weeks before admission to hospital. |
| Cough and sputum for 10 days after teeth extracted; sudden expectoration of foul pus                 | Abscess of right upper lobe; no foreign body                                     | None                      | No  | Thoracotomy for drainage of lung abscess  | Complete recovery   |  | Tooth discharge through wound 5th month after operation.  |
| Tuberculous breathing; rigidity of fingers; hæmoptysis; cough and foul sputum                        | Infiltration of lower left lobe of lung probably abscess                         | None                      | No  | Thoracotomy for drainage of lung abscess  | Complete recovery.  |  |   |
| Purulent sputum; fever; dullness in chest  | Abscess of right upper lobe  | Two weeks                 | No  | Thoracotomy for drainage of gangrenous lung abscess   | Complete recovery.  |  |   |
| Weeks after accident pneumonia, purulent sputum, pain in chest, fever, loss of weight; abscess broke | Large abscess in upper right lobe  | Eight weeks               | No  | Thoracotomy for drainage of lung abscess  | Complete recovery.  |  |   |
| Purulent sputum, 1 cupful daily  | Negative   | None                      | Two pieces of tooth in 6 weeks, filling 12 weeks. | Thoracotomy for drainage of lung abscess. First stage operation   | Uncertain.  |  |   |

# CASES WITHOUT COMPLICATIONS

| Chief symptoms  | X-ray                                | Latent period | Spontaneous expulsion         | Treatment   | Result  | Postmortem                                    | Remarks  |
|---|--------------------------------------|---------------|-------------------------------|---|---|---|--|
|   | Not stated                           | Not stated    | After 3 years                 | None  | Not stated                                    |   | Verdict for plaintiff; damages 750 pounds.   |
|   | Not stated                           | None          | No                            | Bronchoscopic removal   | Died with typhoid fever 10 days later         |   | Tooth impacted. Widal test positive on admission.  |
|   | Not stated                           | Not stated    | No                            | Bronchoscopic removal   | Not stated                                    |   | Tooth difficult to find.   |
|   | Broach just above dome of diaphragm  | Not stated    | No                            | Bronchoscopic removal   |   |   | Lowest position by which a foreign body has been removed by bronchoscopy (Jackson).                |
|   | Tooth                                | None          | No                            | Tracheotomy; bronchoscopy   | Foreign body removed; recovery.               |   |  |
| Of rubber, air to cut off   | Not stated                           | None          | No                            | Bronchoscopic removal   | Not stated                                    |   | Foreign body slipped back into trachea; coughed up.  |
|   | Shadow of metallic body              | Not stated    | No                            | Bronchoscopic removal about 10 days after accident                              | Complete recovery.                            |   |  |
|   | Foreign body                         | None          | No                            | Tracheotomy; burr not found   | Recovery                                      |   | Burr probably coughed up into nasopharynx during tracheotomy anaesthesia. Spat out next day.       |
| Moderate dyspnoea, on pressure  | Bridge                               | Not stated    | No                            | Fluoroscopic bronchoscopy; foreign body removed                                 | Complete recovery                             |   | Ordinary bronchoscopy failed on account of hemorrhage from lung.                                   |
| Cough; soreness   | Not stated                           | Not stated    | Three days after accident     | Bronchoscopy postponed on account of alveolar abscess; jaws could not be opened | Recovery                                      |   | Symptoms not severe enough to warrant low bronchoscopy. Two or three days later broach coughed up. |
| Spasmodic cough   | Not stated                           | Five years    | No                            | Bronchoscopic removal of plaster of Paris from lungs                            | Complete recovery; gained 30 pounds in weight |   | Constricted bronchia dilated.  |
|   | Not stated                           | Not stated    | No                            | Bronchoscopic removal   | Not stated.                                   |   |  |
|   | Not stated                           | Not stated    | No                            | Thoracotomy failed  | Patient died later                            | Tooth found impacted in a secondary bronchus. |  |
| Cough; great prostration; fever; sibilant sputum                        | None                                 | No            | Five days after accident      | None  | Recovery                                      |   | Tooth and crown expelled in violent paroxysm of coughing with hæmoptysis.                          |
|   | Tooth                                |               |                               | Two unsuccessful high bronchoscopies; tracheotomy low; bronchoscopic removal    |   |   | Tooth very firmly impacted; never any symptoms.  |
| Al cough, subterfuge on right; sweating; vomiting; râles; breath sounds | Pleural thickening; fluid right base | No            | About 3 months after accident | None  | Recovery                                      |   | Very little cough and sputum four months after expulsion of tooth.                                 |



## FOREIGN BODIES OF DENTAL ORIGIN IN A BRONCHUS

ings. September 6, 1919, a first-stage operation was done for drainage of the abscess. Portions of the ninth, tenth, and eleventh ribs were resected, and the lung was sutured to the parietal pleura. Pneumothorax had not occurred so far as could be ascertained. A week later an exploratory aspiration was performed for abscess. The aspiration yielded only air which was entirely without odor. Following this negative aspiration the patient began to improve, the cough and sputum practically ceased within a week, and the patient began to gain in weight. It seemed probable that a local pneumothorax had been produced which was sufficient to bring about the good results. A letter from the patient's family physician October 17th stated that she was in excellent condition, but October 30th a second letter was received stating that there was a recurrence of the cough and sputum (Fig. 7).

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## MULTIPLE HEMORRHAGIC FOCI IN BONE

CHRONIC HEMORRHAGIC OSTEOMYELITIS

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THROUGH the courtesy of Dr. Virgil P. Gibney, Surgeon-in-Chief to the New York Hospital for Ruptured and Crippled, the writer is able to report a rare and interesting type of multiple hemorrhagic granulation tissue lesions in bone.

The exploratory operation performed upon the lesions our patient presented, disclosed a highly vascular structure presenting the gross appearance of healthy granulation tissue. The mass completely filled the destroyed areas of bone. This picture is typical of a regenerative effort in its reaction to injury.

Because of the gross appearance of the process and the histopathologic data the microscopic studies revealed, the title given this paper of multiple hemorrhagic foci in bone, or chronic hemorrhagic osteomyelitis, seems the most fitting designation for the presenting pathologic pictures. The cause or causes of the initial destructive process or injurious agent or agents bringing about these reactions or responses to injury will be discussed further on. What it is wished to particularly emphasize here is the well-established view expressed in modern pathologic studies, that inflammation is a reaction to injury, evidenced by attempts at repair.

A primary effort at regeneration and reconstruction in all connective tissue processes always has for its beginning the formation of granulation tissue. Such a process in bone is very properly termed an osteomyelitis even though there is no evidence presented of pus or pus formation. The view that the formation of granulations in any lesion or lesions is confirmative of an attempted repair seems beyond dispute.

We are able to show definitely in our case of multiple lesions and in numerous instances where complete studies of the solitary inflammatory process has been made, that they exactly simulate and conform to all the criteria presented governing a diagnosis of granulation tissue structure.

All available evidence points to the conclusion that these pathologic conditions are the result of and follow bone destruction. The known etiologic factors bringing about bone destruction and producing the various forms of osteomyelitis are the spirochæte, tubercle bacillus, infectious bacteria and parasites, traumata, malnutrition, and metabolic change, apparently due to endocrinal glandular lack of balance. The grade or degree of such osteomyelitic process cannot always be determined from clinical findings.

The case presented herein makes the fourth published in American medical literature, in which multiple hemorrhagic foci (hemorrhagic osteomyelitis) have been studied in their gross and microscopic pathology.

CASE I.—Crile and Hill were the first to record a case of multiple bone lesions presenting similar findings, under the title of "Multiple Giant-Cell Sarcoma." The patient was a young unmarried woman, aged twenty-two years. X-ray pictures taken of the skeleton showed numerous bones involved in the pathologic process. Operation was performed on a lesion in the right tibia, and the contents studied from its gross and microscopic pathology. The findings presented a picture from which a diagnosis of multiple giant-cell sarcoma was made. No direct etiologic factor or factors were ascertained. The history of the case, in part, states that the patient's mother had suffered from syphilis; her father had diabetes. She had chronic discharge from ear since childhood. No evidence of acquired syphilis. Had been under specific treatment for some time without improvement. It is interesting, however, to note that the exploratory wound gave no evidence of healing until the patient was put upon iodide therapy; prompt healing of the wound then resulted.

Ten years after the above findings were reported by Crile and Hill, the same patient was seen in New York by Dr. I. S. Hirsch, who has been kind enough to furnish me with the following data:

"This patient turned up in Bellevue Hospital in 1915 or 1916, with numerous masses, apparently attached to all the bones.

"A radiographic examination showed multiple multilocular cystic tumors, which had the typical appearance of what we now recognize as giant-cell tumors or multiple fractures. The patient was in good general condition."

The second case appearing in American literature, presenting a similar gross and microscopic pathology, was first published by Adolph Hartung in 1914, under the title of "Some Unusual Bone Lesions," in diagnosis of bone cysts being made from the röntgenologic pictures obtained for study.

CASE II.—The same patient was presented in 1915 by Kanavel at a meeting of the Chicago Surgical Society. Kanavel had operated upon two of the lesions, and reports, in part, as follows:

"In both cysts removed we found a granulomatous type of tissue; it was rather tenacious, and around each one of these cysts was a thin lamella of bone. In both cysts the lamella of bone was broken down and the cyst material scraped out. One cyst was packed on account of bleeding and the other was closed."

The study of the microscopic sections, made by Bissell, taken in connection with Kanavel's description of the gross pathology of the lesions in this case, would seem to group it with those of Crile and Hill, Haussling and Martland and the one here reported by the writer.

Hartung and Kanavel's patient was a male, aged thirty-four years. The lesions began developing nine years previously. The diagnosis of multiple bone cysts does not seem justified, in view of Kanavel's findings of vascular osteomyelitic foci.

A careful study of many solitary lesions in bone has impressed and confirmed the writer in the view that practically all fibrocystic and cystic

## MULTIPLE HEMORRHAGIC FOCI IN BONE

lesions are secondary processes and further that most of them arise from granulation tissue, this latter structure representing a primary effort at replacement in destroyed areas.

As pointed out by Fuller, in discussing Kanavel's case, the term "bone cyst" is quite misleading and it is usually incorrect. One should never be content to rest upon a diagnosis of "bone cyst" from X-ray findings alone. The latter frequently exhibits an area or areas of osteolysis, in pathologic processes in bone, commonly termed bone cyst, or cysts, that covers other definite diseased conditions.

The röntgenologist unfamiliar with the gross and microscopic pathology attending bone lesions is handicapped in reaching confirmatory diagnostic conclusions, particularly by dependence upon X-ray studies alone. It should also be borne in mind that even possessing such special knowledge the röntgenogram must frequently fall far short of expressing the true pathology many lesions present. The X-ray is of inestimable value as a diagnostic aid, but, as a rule (excluding fractures), positive conclusions should not be made regarding bone pathologic processes regardless of other cumulative findings.

In the opinion of the writer, it is more than probable that operative investigation of cases termed "multiple bone cysts" would develop a greater number exhibiting lesions of the type here reported. The writer is also of the opinion that a progressive effort at repair in these hemorrhagic osteomyelitic processes is evidenced by the formation of fibrous tissue with cystic areas. Such so-called cysts usually result from contraction, due to granulation tissue metaplasia, rather than from tissue degeneration.

It may readily be assumed that where multiple lesions of this character present themselves, different phases of the affection showing efforts at repair are to be observed, not only in the different lesions but in structures in a solitary process.

The findings of highly vascular granulation tissue and microscopic giant-cell content in one area in Crile and Hill's case, which they termed "multiple giant-cell sarcoma," should not lead to the assumption that each of the other lesions necessarily presented an exact gross or microscopic similar pathologic picture.

The cases reported by Percy, Willard and Andrus, Da Costa, Funk, Bergeim and Hawk, and numerous other observers, while apparently closely allied in relation to the etiologic factors bringing about these multiple destructive processes in bone, cannot be included in this group because no evidence is presented exhibiting attempts at repair by the formation of vascular granulation replacement tissue.

It is in connection with the appearance of this reparative hemorrhagic structure filling destroyed areas in bone that much confusion has arisen and in which seemingly errors of diagnosis have frequently been made. The belief that such masses are in themselves sarcomata, is based generally upon the fact that numerous giant cells are frequently present.

Recent studies and research apparently show rather definitely that the type of giant cells contained within such masses have no tumor forming power. Their function seems to be altogether scavenger. They also appear to occur in the greatest profusion in areas of ancient hemorrhage, acting as phagocytes. To a much less degree they are found in areas of cellular necrosis and fibrosis.

The third case belonging to this group is the one of Haussling and Martland. They describe the clinical picture in their study as resembling a multiple myeloma. Bence-Jones protein bodies were never found in the many urinary examinations made nor were any abnormal blood conditions present, spinal fluid tests were also negative. The microscopic and gross pathologic studies of the removed tissue finally proved the lesions to conform to the pictures presented in the so-called medullary or myelogenous giant-cell sarcomata, or multiple chronic hemorrhagic osteomyelitis of Barrie.

**CASE III.**—The patient was a female, aged twenty-five years, married, four normal births, one miscarriage (last normal delivery of a full-term healthy child one month before admission). Nine months before admission suffered from fracture of lower end of right femur; normal recovery. Examination of the patient elicited palpable masses in the right orbital cavity and superior maxilla (observed many months), right and left clavicles, left tibia and seventh rib on right side. Röntgenograms taken of the skeleton showed, in addition to the above, areas of osteolysis in right femur, right and left fibula, right humerus and pelvis.

All lesions were operated upon, curetted thoroughly and closed. They healed by first intention and gave no later evidence of infiltration. With the exception of the humerus, all the processes presented a gross picture of firm, red, granulation tissue. The lesion in the humerus was fibrocystic in character.

This interesting case is again under observation by Haussling and Martland, four years after operative interference. They state the patient is in good condition and are about to publish a supplementary report on the case.

**CASE IV.**—This patient, while on his way to the hospital for observation and treatment, was run into by an automobile truck and had two ribs fractured.

**History.**—November 21, 1919. George M., male, white, Russian Hebrew, aged fifty years, married; youngest child eighteen years old, wife has not had any miscarriages; denies venereal infections.

Fifteen years ago had an attack of "sciatic rheumatism" lasting one year. Eight years ago first felt weakness and pain in both legs with sticking pains in soles of feet, trouble lasting two months. The following winter suffered from a repetition of same symptoms more severe in character, lasting for same period of time. During both attacks had difficulty in going up and down stairs and continuously had feeling of exhaustion. No urinary symptoms nor gastric crises. Six years ago all teeth were extracted in hope that pain in feet and legs might be relieved. For past six years has been laid up every winter because of disability of lower extremities. During summer months has always been free from pain but suffers



FIG. 1.—Anterior and posterior views of patient described.



FIG. 2.—X-ray showing thickened skull with translucent spots.

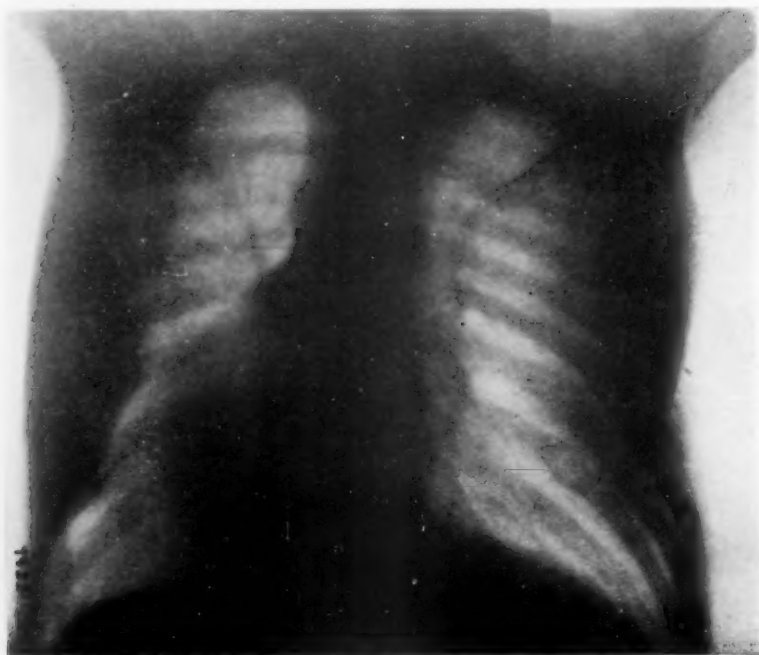


FIG. 3.—X-ray showing areas of osteolysis and fractures through pathologic processes in both ribs.

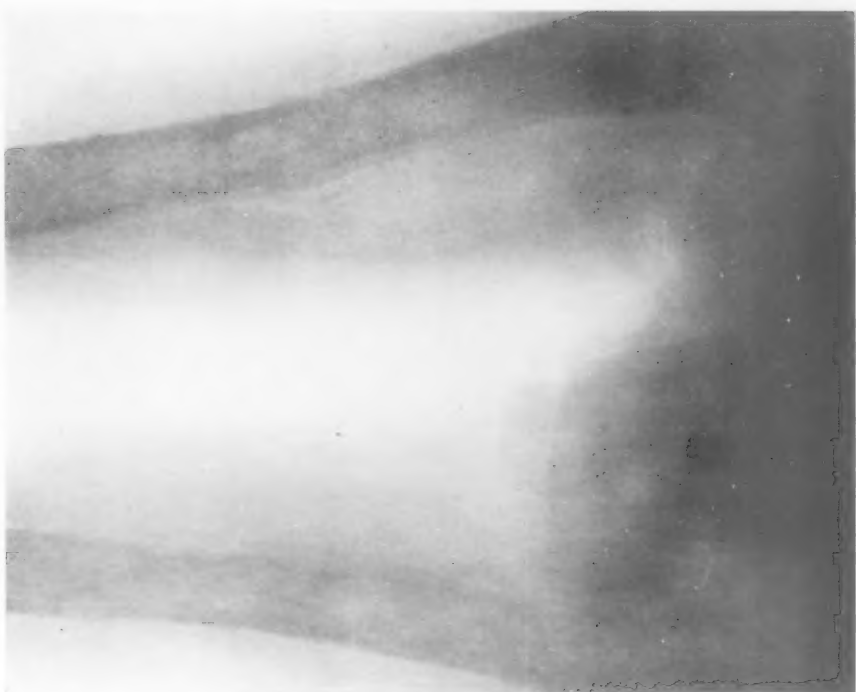


FIG. 4.—X-ray showing areas of osteolysis and translucency in both femora.

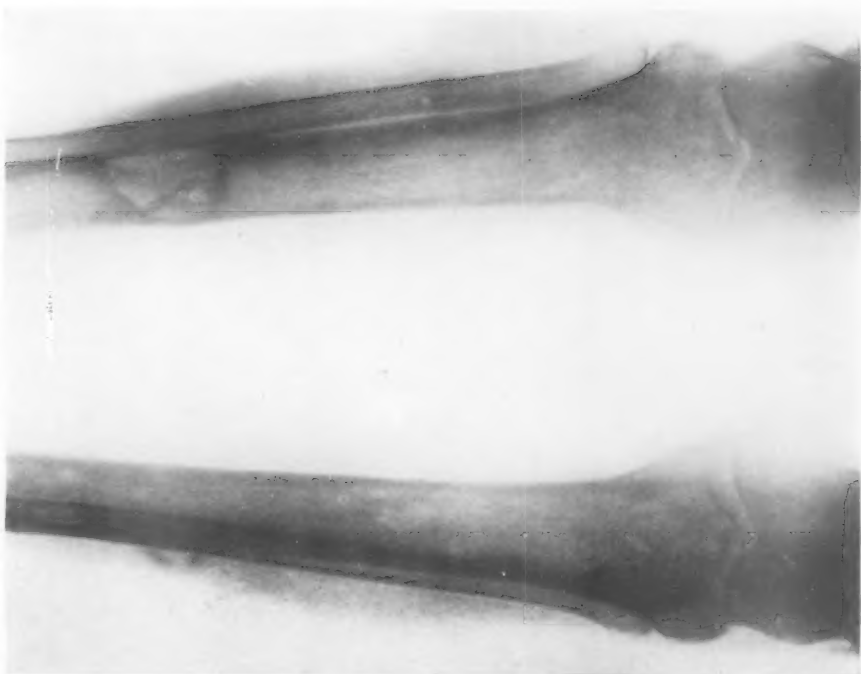


FIG. 5.—X-ray showing large area of osteolysis in left tibia; areas of osteolysis and translucency in right tibia.

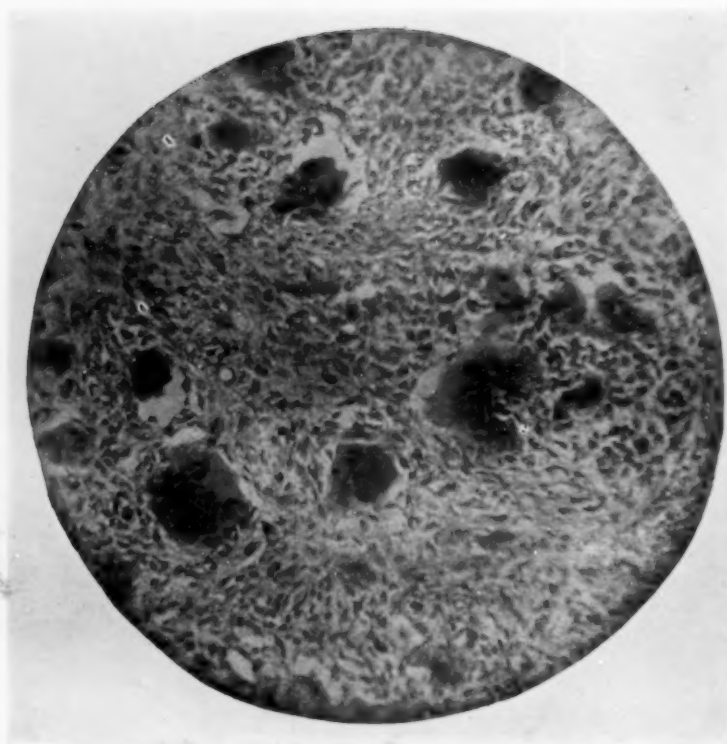


FIG. 6.—Multiple hemorrhagic osteomyelitis from tissue removed from tibia. Low-power photomicrograph.

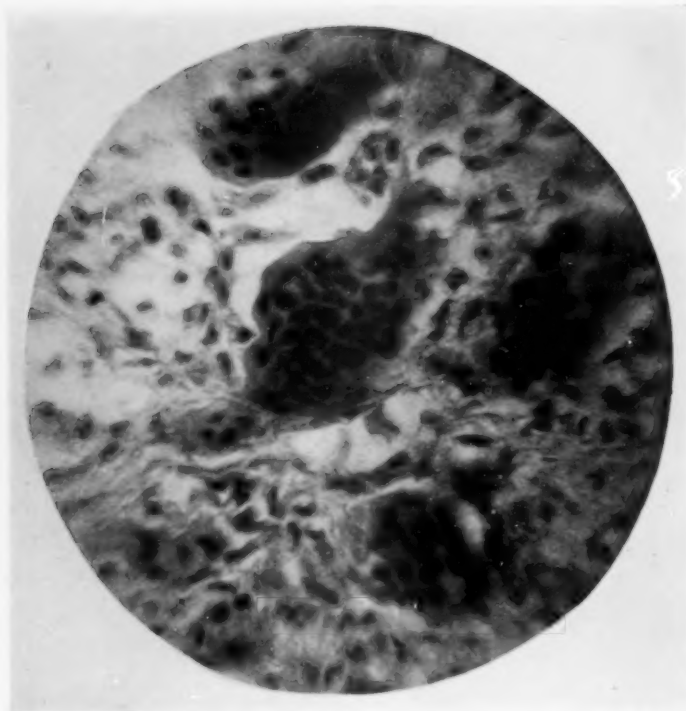


FIG. 7.—Multiple hemorrhagic osteomyelitis tissue from same patient. High-power photomicrograph.

## MULTIPLE HEMORRHAGIC FOCI IN BONE

from same feeling of exhaustion. Has never suffered from headaches. In 1915 a neurologic diagnosis of amyotrophic lateral sclerosis was made; at that time patient exhibited weakness in left arm and leg, with marked muscle atrophy of left hand and both legs.

Patient is certain that nodules in legs have been present less than a year. Has had great difficulty about eating since using false teeth.

*Examination.*—Patient's apparent general condition not especially good. Neurologic examination negative. Head not enlarged, upper extremities negative. Pressure over eighth, ninth, and tenth ribs beyond axillary line causes excruciating pain; abdomen negative; urologic examination shows chronic vesiculitis. Tenderness upon pressure over right femur, pressure over left causes severe pain. Enlargement size of a hazel-nut in upper fourth anterior surface right tibia, also localized area of tenderness lower fourth same bone. Left tibia exhibits enlargement size of a hen's egg mid third anterior surface.

*X-Ray.*—Exhibits areas of osteolysis in long bones of lower extremities, ribs on right side and small area in the thickened skull. Ribs fractured through pathologic areas.

Blood and spinal fluid Wassermann negative. Differential blood-cell counts negative. Numerous urinary examinations for Bence-Jones protein bodies were negative.

In spite of the negative Wassermann findings, the writer made a diagnosis of multiple gummata, and had patient put upon specific treatment which was pursued for several weeks without apparent improvement and was dropped because of a developing nephritis which cleared up on disuse of the specific treatment. Several members of the hospital staff regarded the process as one of multiple myelomata.

The patient consented to an exploratory operation, which clarified the diagnosis. The gross appearance of the pathologic tissue exhibited the typical picture of a hemorrhagic osteomyelitis, which was later confirmed by microscopic study.

*Operation.*—A vertical linear incision 3 inches in length was carried through skin to bone over the site of lesion in the left tibia. A wedge of bone  $2\frac{1}{2}$  by 1 inches was then removed, exposing the highly vascular soft tissue contents. There was no lining membrane, the structure being firmly adherent to the bony mural surfaces. Thorough curetting caused such profuse hemorrhage that it was found necessary to firmly pack the cavity for forty-eight hours, after which closure was made under novocaine anæsthesia. Healing was primary.

Histopathologic reports by Professor Ewing, Doctor Martland, Doctor Jeffries, and others are uniform in their findings regarding the cellular picture of this lesion. Doctor Ewing states:

"The section of bone tumor which you sent me shows the structure of what is commonly called benign giant-cell sarcoma of epulis type. It is composed almost entirely of the characteristic giant cells,

many of which surround empty spaces which are often apparently blood channels. With the giant cells are an unusual number of large clear cells resembling endothelial cells from which apparently the giant cells are forming. Here and there are small fragments of bone undergoing simple absorption, in which process the giant cells do not seem to be participating. There is very little stroma and there are very few of the small spindle cells which make up a good portion of many such lesions.

"I have no objection to interpreting such a lesion as inflammatory, yet many of these processes have more definite features of a neoplasm."

It is, of course, altogether too speculative to venture an opinion regarding the causative factors that have brought about this patient's systemic bone disease. Some points noted in the history are, however, suggestive.

First, the condition of the patient's teeth was so bad several years ago that all were removed. One may quite readily conceive of the possibility of a general hemal infection arising from this cause. One may also understand that certain strains of vegetative bacterial growth possessing exceedingly low-grade virulency may perhaps have a selective predilection for tissues rich in mineral salts. The drawback to this hypothesis is that bacteria have not been observed in lesions of this type.

The second suggestive causative factor in our case is the fact that following removal of the patient's teeth he has had difficulty in masticating with an artificial set, has suffered great discomfort, and states that he has been unable to partake of the various foods necessary for health. In other words, since the removal of his teeth he has been in a state of under-nutrition and has slowly and steadily lost weight. Numerous experiments have definitely shown that food intake deficient in lime salt content is always reflected in the production of bone changes similar to some of the "malacias of von Recklinghausen." It seems probable that this case belongs in the same group. Since our patient has been put upon a generous diet, rich in lime salt content, and daily intake of 15 grains lactate of calcium, his general physical appearance has much improved.

The pathologic pictures the vascular granulation tissue masses exhibit, while recognized as being secondary processes, should be regarded as separate definite distinct entities, they are new regenerative efforts that have for their object restoration of destroyed areas.

In order to exactly cover the pathology that these products of reaction to injury present, both in their gross and microscopic studies, the term "multiple hemorrhagic osteomyelitis," while perhaps not altogether euphonious, seems the most fitting and scientifically correct term to use. The multiple lesions of this character do not lend themselves to the view that the condition is malignant nor do they conform to the latest definition of a tumor as propounded by Ewing, broad as his definition is, namely, "a tumor is an autonomous new growth of tissue."

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Foreign literature contains many detailed reports of cases and studies of the pathology of these multiple lesions; the Germans and Austrians record the greatest number of observations. This is probably largely due to the pioneer work of von Recklinghausen and the stimulus his studies gave those interested in bone pathologic conditions. One still finds voluminous quotations regarding *ostitis fibrosa*, as described by him in 1891, but very few regarding his revised views given in great detail in his unfinished work published in 1910. Many observers have reported the multiple lesions containing vascular granulations as bone cysts, but always have associated such so-called cysts with *osteomalacia*, *ostitis fibrosa*, *ostitis deformans* and cysts in so-called giant-cell sarcoma.

Rehn, in 1904, was among the first to observe and describe a case belonging to the group under discussion. The gross and microscopic pathologic findings in his case coincide with the pictures of so-called myeloid sarcoma, giant-cell sarcoma, myeloma, giant-cell tumor and hemorrhagic osteomyelitis. His paper was published under the title of "Multiple Knochen Sarkome mit Osteitis Deformans." Bloodgood regards this contribution with its studies of microscopic findings as one of the best in foreign literature. Bloodgood also gives a résumé of the foreign literature covering these multiple lesions up to 1910. He has grouped them under the general headings: Multiple Cysts, *Ostitis Fibrosa*, Giant-cell Sarcoma. He found 23 cases reported, as follows:

|  |           |
|--|-----------|
| Multiple cysts in <i>ostitis fibrosa</i> .....   | 12 cases. |
| Multiple cysts in <i>ostitis deformans</i> ..... | 5 cases.  |
| Multiple cysts in <i>osteomalacia</i> .....      | 6 cases.  |

He states that in 7 out of the 12 cases in the first group, giant-cell tumors were noted; a further observation states that in the disease affecting the general skeleton, the cyst formations are apt to be smaller and the giant-cell areas more numerous and larger. So-called giant-cell tumors were also reported in the anatomic studies of cases diagnosed as *osteomalacia*.

Bloodgood expresses the view in his paper:

"There is no doubt that the bone cyst, *ostitis fibrosa*, and the giant-cell sarcoma may be a disease localized to one bone."

The writer regards the above changes, observed in bone lesions of this character, as different phases only, of the process of attempted repair following bone destruction. The initial cause of such destruction in the multiple groups is still a subject for further investigation and study.

The lesions described as giant-cell sarcoma and *ostitis fibrosa* in bone present a picture it seems impossible to disassociate from a regenerative process in connective tissue. The gross and histopathologic studies of the areas described as sarcomatous give all the criteria of structure we know to be granulation tissue (a primary effort in the process of repair and restoration). So-called *ostitis fibrosa* also gives the evidence proven

in other lesions, of a secondary reparative progressive stage, in which the granulations have become fibroblastic and a metaplasia from granulation into fibrous structure has taken place. It may be definitely stated that the masses of hemorrhagic structure with their giant-cell content, termed myeloid and giant-cell sarcoma, myeloma and hemorrhagic osteomyelitis, give all the known evidence that we possess of an effort at bone restoration.

Exactly the same sort of picture in both gross and microscopic studies may be observed in the reaction following fracture of a bone.

Bland Sutton made the statement several years ago:

"All who have studied histologically the exuberant material of repair around the seat of a fracture in a long bone, know the difficulty in deciding whether the new tissue is innocent or malignant."

He also expressed the opinion:

"I have come to the conclusion that some bone cysts in the long bones of children represent myelomas (so-called giant-cell sarcomas and giant-cell tumors) that have undergone spontaneous cure."

The writer advanced the same belief in a paper published in 1912.

The view frequently expressed, that the so-called giant-cell sarcoma (hemorrhagic osteomyelitis) has its origin in the multiple lesions, in areas of fibrous ostitis, does not seem to be well founded. It appears more reasonable to regard the vascular masses, encountered in these affections, as areas of ordinary granulation tissue; a primary structure, which has not progressed to fibrosis. The contrary view seems rather like "placing the cart before the horse." Nor is there any foundation for regarding such hemorrhagic structure as neoplastic. The presence of giant cells of the type observed in these tissues are certainly no criteria either of neoplasia or malignancy. As it is impossible to demonstrate either malignancy or neoplastic power in the type of giant cell found in the tissues of these so-called giant-cell sarcomata, there seems no reason to doubt that the hemorrhagic structure is just what its histology indicates—ordinary granulation tissue.

The presence of numerous giant cells in pathologic procession in bone, and especially in affections non-suppurative in character, has in the past been the real factor in ascribing malignant autonomous growth to such inflammatory lesions. In the light of present-day study and research, this view seems to have very largely lost ground, giant cells of the type prevalent in processes giving the picture of a vascular benign lesion being now generally regarded as having only scavenger or foreign body function. Mallory is very definite in his belief both as to their origin and function.

Elmslie reports in detail some of the cases from foreign literature recorded by Bloodgood and presents additional patients coming under his own observation. He also gives a list of references covering both the solitary and multiple lesions collected from American and foreign litera-

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ture. Elmslie's view that von Recklinghausen's grouping of all these lesions, under the term "malacias," is too broad, seems to be well taken. One cannot, however, accept his (Elmslie's) conclusions that diagnoses of the different type lesions may be made from the site in bone such lesions occupy.

Martelli reported a case in 1912 that evidently comes under the affections cited in this paper. The writer has been unable to obtain the article for study and comment.

Molineus published a critical study of three cases he had observed. They were all females, aged respectively seventy-four years, fifty-eight years, and forty-five years. The two older patients were married, the youngest was single. He regarded them as belonging to the group of malacias of von Recklinghausen. He noted a definite hyperplasia of the parathyroids in each of the cases. The multiple brown epulis sarcoma-like tumors occupying different areas in the bones, he did not regard as definite new growths, but considered them as masses of hyperplastic tissue brought about and being incident to the irritative and destructive processes present and occurring in the bones.

In analyzing the studies presented in foreign literature concerning these multiple pathologic processes in bone, one notes that many of the lesions contained within their lumen large areas conforming to what has been in the past regarded as sarcomatous neoplasia. The diagnoses in numerous instances, however, are grouped and rest upon such terms as multiple bone cysts, cysts in *ostitis fibrosa*, cysts in *ostitis deformans*, and cysts in *osteomalacia*. The so-called giant-cell sarcoma content has apparently not been regarded of sufficient consequence, importance, or value to place such lesions definitely among the neoplasms of bone. While it must be recognized that the solitary local process and the multiple systemic lesions give exactly similar gross and microscopic pathologic findings, it also seems quite clear that the etiologic factors bringing about these identical appearing conditions are varied. In a great majority of the solitary lesions the etiologic factor in their production seems to have been bone trauma. This factor obviously cannot account for the multiple processes. von Recklinghausen regarded the systemic multiple lesions as being due to and an exhibition of different forms of "malacia."

In recent times observers and investigators incline to the view that the multiple processes have their origin in endocrinal glandular disturbance and faulty nutrition, such conditions causing lack or loss of equilibrium in the chemistry of bone balance; others suggest they are the result of systemic bacterial infections. The rôle the spirochæte or tuberculous bacillus may play has not been demonstrated. Where Wassermanns have been taken, negative results have always been reported.

Of paramount importance are the pictures these lesions present at operative intervention; equally so are the gross and microscopic patho-

logic studies. Particularly important is the phase of the process that exhibits the highly vascular tissue masses, generally mistakenly regarded as myeloid or giant-cell sarcoma.

Ziegler's description of granulation tissue conforms in every respect to the structure under consideration.

He states:

"The inflammatory proliferation of tissue is essentially a regenerative process which has for its aim the compensation of the tissue lesions produced by the causes of inflammation. Under especial conditions, it leads not infrequently to a hyperplastic proliferation of connective tissue, frustrates its own aim and causes new damage. This is particularly the case when, as the result of the persistence of the cause of the inflammation in the organism, there is kept up a permanent condition of inflammation."

He further states:

"The granulation tissue which forms in the course of an inflammation is nothing more than an embryonal tissue arising through cell proliferation and infiltrated leucocytes. Primarily it consists of cells and newly formed vessels. The young embryonal tissue is richly supplied with blood-vessels which give to it its red appearance."

He also notes the presence of giant cells with the other cells composing these granulation tissue masses.

The many studies and descriptions of regenerative inflammatory processes recorded by early and modern investigators, from the time of Cohnheim, Burdon Sanderson, Green, and Ziegler to present-day students of the subject, including Francis Carter Wood, Adami, Mallory, Ewing, and others, are all in accord in their views and presentations of pictures describing inflammation and regenerative granulation tissue proliferation. The descriptions thus presented correspond in all particulars to the pathology of the so-called medullary giant-cell sarcoma.

Experimental studies give evidence that one may without difficulty produce these mistakenly termed neoplastic processes at will, by following the technic suggested by Barrie.

Ribbert's latest conclusions state: "A tumor cannot be produced experimentally without existing predisposition thereto."

Under the title "Benign Giant-cell Sarcoma, Epulis Type," Ewing states as follows:

"As the spindle cells of the stroma become more active and abundant, the giant cells diminish, the tumor shows less resemblance to granulation tissue, but becomes firmer and like spindle-cell sarcoma."

This statement is illuminating in that Ewing describes changes taking place in the granulation tissue mass, that later gives the appearance of spindle-cell sarcoma. A change from inflammatory into neoplastic tissue.

One must, of course, recognize the potentialities for neoplastic growth in any chronic process, particularly in primitive tissue. It, therefore, should not be unexpected if in these conditions there is occasionally en-

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countered a lesion undergoing degenerative malignant proliferative change; such malignant transformation, however, must be infrequent in the processes under consideration.

The writer has personally observed 35 cases of the solitary affection, only one of which has given any evidence of neoplastic change.

A colleague made a diagnosis of hemorrhagic osteomyelitis at operation from the appearance of a focus in the lower end of the radius in a patient aged thirty-one years. The tissue removed was a reddish-brown colored liver-like substance. The opportunity was given the writer of seeing the X-ray in this case, taken before operation, who had no hesitancy in regarding the process revealed as a true medullary sarcoma. This diagnosis was confirmed on later examination of the microscopic section, the latter exhibiting the typical appearance of a fibrosarcoma within which neoplastic structure, very numerous giant cells of the scavenger type were observed. The gross pathology in this case would lead one to regard the sarcoma as probably having arisen in granulation tissue. In sarcomatous processes, so well pointed out by Mallory, it is the stroma that presents malignant degenerative proliferation, not the osteoclasts or scavenger giant cells.

From our studies and reading of the literature covering the subject, we have reason to believe that occasionally, though rarely, processes exhibiting vascular granulation tissue masses in bone, particularly where the areas are of large size, may take on degenerative proliferative malignant change, by transformation of primitive granulation into neoplastic structure (usually fibrous in character). Such change always shows an increase of tissue beyond normal efforts, bounds, or control, with absolute evasion of regular structural architectural cellular arrangement. It is our contention, however, that one is not justified in regarding these hemorrhagic granulation tissue processes as neoplastic until neoplasia is proved; it is our further belief that malignant degenerative change in such cases is exceedingly rare.

Butlin's studies published forty years ago are still quoted frequently regarding the diagnosis of these lesions. He apparently based a diagnosis of sarcoma in these vascular processes on their giant-cell content alone. He believed that as much as four-fifths of the bulk of a mass might be composed of giant cells and also ascribed the maroon red color of the lesions as being due to the presence of such cells. In our experience both contentions seem incorrect.

A definite diagnosis of multiple hemorrhagic foci in bone (hemorrhagic osteomyelitis) in the present state of our knowledge is only possible through operative intervention. As a diagnostic aid the use of the X-ray is essential in exposing areas of osteolysis caused by injurious agents. One is frequently unable, however, to differentiate from the radiograms alone, between multiple myelomata, multiple gummata, multiple hemorrhagic osteomyelitis and perhaps metastatic carcinomata of bone.

The clinical data obtained from tests made of blood, serum and urine, together with the gross physical appearance of lesions observed upon clinical examination, are in some instances sufficient to reach diagnostic

conclusions, but final diagnosis rests upon gross and microscopic pathologic findings. Neither multiple myelomata nor the metastatic carcinomata give the picture of granulation tissue and giant scavenger cell content obtained in multiple hemorrhagic osteomyelitis.

Treatment of the multiple lesions, until recent years, does not appear to have received much attention. Curetting, as practiced by Kanavel and Haussling and Martland, appears to have been beneficial and should be recommended where lesions are localized and readily reached. The writer would urge further efforts in attempts at the discovery and removal of the constitutional cause or causes, whatever they may be. McCrudden's chemico-pathologic studies regarding the etiology of osteomalacia open up a field in this direction, as do also the work and studies of those interested in endocrinal glandular phenomena.

Ewing is very enthusiastic as to the value of radium as a therapeutic agent in all lesions of this character.

In our case, Coley's toxin was given under the latter's direction for several weeks.

The feeling of the writer at the present time regarding therapeutic measures in cases exhibiting the multiple processes is that where lesions are accessible for curetting, such should be performed; where inaccessible for surgical procedure, radium may be tried, or Coley's toxins used. Perhaps more important than anything else in the treatment of cases of bone disturbance of this character will be methods having for their object the restoration of nutritional lime-salt equilibrium. These bone conditions are exceedingly chronic and insidious in their onset; that they, in fact, shorten life, does not seem to have been demonstrated.

#### CONCLUSIONS

1. Hemorrhagic foci in bone (hemorrhagic osteomyelitis) should not be considered as neoplasia, producing bone destruction, but rather as regenerative granulation tissue masses whose end effort is restoration of areas already destroyed by some injurious agent.
2. The etiologic or exciting factors in destruction observed in the multiple processes are not yet fully determined. Endocrinal glandular disturbance, poor lime-salt nutrition, the spirochæte, and other bacterial infections seem to partake in the etiology of such lesions.
3. The solitary lesions presenting a similar gross and microscopic pathologic picture, in a great majority of instances, give a history of bone trauma.
4. The affections responsible for the production of processes of the multiple type are low-grade chronic systemic diseases that apparently do not definitely shorten the life of the individual to any demonstrable degree. The cases noted in literature have all given histories of many years' duration.

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5. The arrest of repair in which the granulation tissue remains as such without progressive metaplastic change into fibrosis, or the end product bone, is apparently partly due to insufficient formation of fibrogen, thus preventing chemotactic balance.

6. These lesions, because of their primitive structure, may be regarded as possessing potentialities for neoplastic change, but malignant transformation must be very rare; when such does occur, the scavenger giant cells apparently take no part and are frequently greatly lessened in number.

7. That lesions of this character should be regarded as low-grade inflammatory reparative processes and classified accordingly among the regenerative inflammations in bone.

8. Delay or arrest of repair in these processes, as evidenced by the continuous presence of highly vascular structure, seems to be due to a lack of chemotactic balance, local or general.

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## COMPRESSION FRACTURES OF THE LOWER END OF THE RADIUS

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THE laws applying to the mechanics of materials apply to fractures in bone as regards stresses or strains just as they do to other substances which have been tested experimentally to determine the breaking strain. They conform closely in their type to fractures in wooden beams which are possessed of fibre structure, because bone is made up of fibre material with various salts of calcium, potassium, magnesium, and iron. It is not entirely granular like iron or steel.

A study of elementary applied mechanics would be of advantage to most surgeons.

1. Compression stress is the driving together under compression of the molecular structure up to the breaking moment, and then the sudden collapse of the entire fibre structure of the substance. There is little slivering, the fibres simply go to pieces in fibre structures, and in steel or iron or granular substances it may break into wedges or fly into small pieces like an explosion, as it does in granite. The structure itself has disintegrated.

2. Tension stress: The molecular structure or fibre is pulled apart, there is no collapse of the structure, or if granular like steel, there is no tendency to fly into pieces. There are many lines and fissures usually, and one deeper crack which widens more or less transversal, but there is usually slivering in fibre structures and the fibre structure is not disintegrated; it is simply pulled apart on the tension side of a transverse break.

3. Torsion stress is twisting stress and follows pretty definite rules applying to stresses and strains. There is also the slip in fibre structure, a compression on one side, and a tension on the other, and the tendency to split longitudinally the whole length of the structure, a separation through the neutral axis. This does not usually apply to bone. There are, however, to be taken into consideration the sheering stresses where one material is sheered off by the more or less sharp edge of a substance, one or both substances being under compression. These are about all the forms of stresses and strains with which we have to deal as surgeons.

Since writing this article I have read a paper by Speed who has dealt with this subject in a very able manner, although I think he has fallen into the error of most of us of attributing too much importance to the tensile character of fracture in bone.

If you break a dried stick by bending, you impose two strains; a compression on the side of concavity and tension on the side of convexity. The stick begins to part always on the side of convexity, a

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tension fracture, the molecular arrangement of the substance is pulled apart. It seldom or never breaks on the side of compression at the breaking moment. Compression and tension are equal as they are always equal in these transverse breaks. These fractures are not always, however, analogous to fracture in bone, and that is the point where many of us, myself included, have been making mistakes, because as medical men we seldom have time or inclination to dig deeply into other branches.

If you will examine closely Fig. 1 you will get a pretty definite idea of a tension fracture in fibre structure. But it has been found experimentally that when we use comparatively short lengths of green fibre

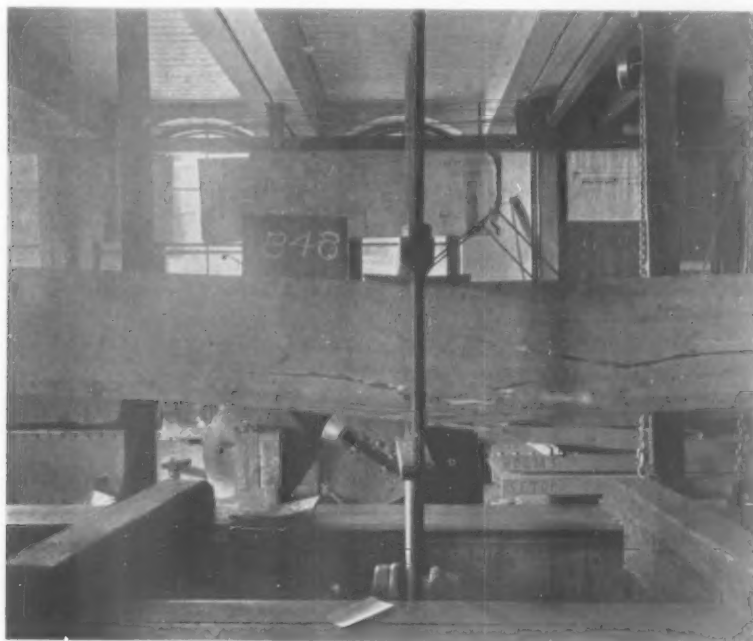


FIG. 1.—Tension break in fibre material. Note splintering on tensile side. No destruction of fibre.

material and apply axial compression in the testing machine we get no such break. Instead of a tension fracture, we get in nearly every instance at the breaking moment an entirely different complex, a compression fracture, the whole fibre structure on the concave side, the compression side, simply lets go and goes absolutely to pieces. There is no splintering, there is no driving together of wedges and splinters of material, telescoping, impaction, the structure simply disintegrates and loses all cohesion. This is a compression fracture.

For the purposes of this article, a discussion of the mechanics and treatment of those fractures of the lower end of the radius which have been called Colles for so many years, and which we contend should be called compression fractures of the lower end of the radius, because that

terminology would instantly visualize the mechanics of the injury, and to refute, as we believe we can, the idea which is universal, that there is a great amount of impaction in these fractures, it is necessary that we have this clear idea of the difference between tension and compression breaks, and if we have this, we shall be able to see and appreciate as we look at Fig. 2 exactly what has happened to this great beam tested in the machine at the Massachusetts Institute of Technology, showing a typical compression break with actual disintegration of the entire fibre structure on the side of compression, and shall thus be able to apply it to our problem. Glance at Figs. 3-9 and 10, X-ray plates of Colles' fractures with what we

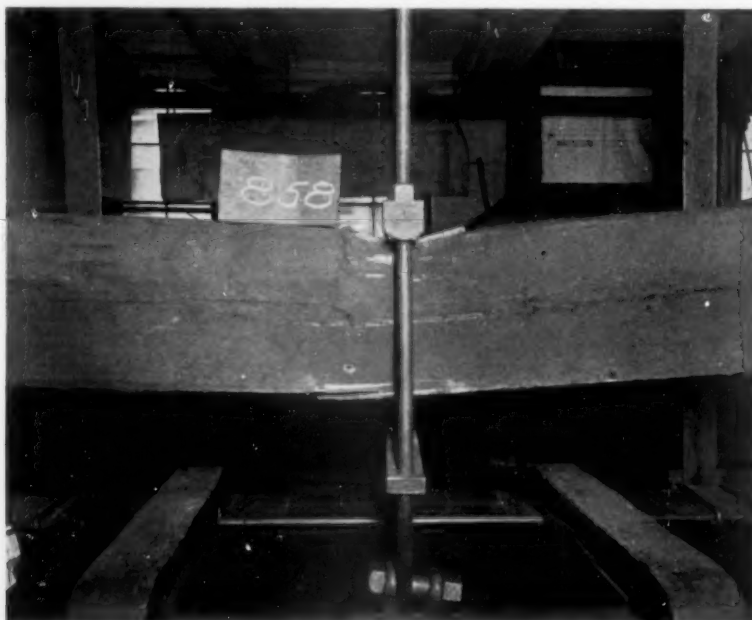


FIG. 2.—Compression fracture in fibre material. Note collapse of structure on compression side. Is this not a typical Colles fracture with so-called impaction?

have been pleased to call impaction, and you will observe the great similarity which they show to this beam broken under compression. They show typical impaction in this type of fracture, yet there is no impaction, as proved by the reduction and the mobility under local pressure. Neither is there any impaction in any Colles' fracture, since by impaction we mean telescoping, and that would mean rigidity in all cases showing this type of deformity. Instead there is actual disintegration and loss of substance just as there is here. The fibre structure has been crushed, disintegrated more or less, and there is nothing to impact.

Call it crush, if you wish, and you will be correct, but do not call it impaction. This is proven because after reduction these cases will still show the same change. If impaction occurs it is obvious that the frag-

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ment cannot be dislocated backward or in any other direction. There may be a different set to the planes of the articulation, but there can be no greatly dislocated fragment. There might also be impaction after dislocation, but it would be more impingement than impaction. In order to reduce these it would have to be broken up, but it would not show to any great extent after reduction, since it would not then be impacted. Take your X-rays of bad cases after reduction and you will see that what the X-ray men and the surgeons call impaction still remains, but you will know that, since the fragments move easily, there can certainly be no impaction. There still remains the antero-posterior change of plane in the articulation, due to the compression with its loss of fibre structure and a certain amount of this loss is always permanent. The mechanics of these fractures has been for years a debatable subject, arrachement, sheer,

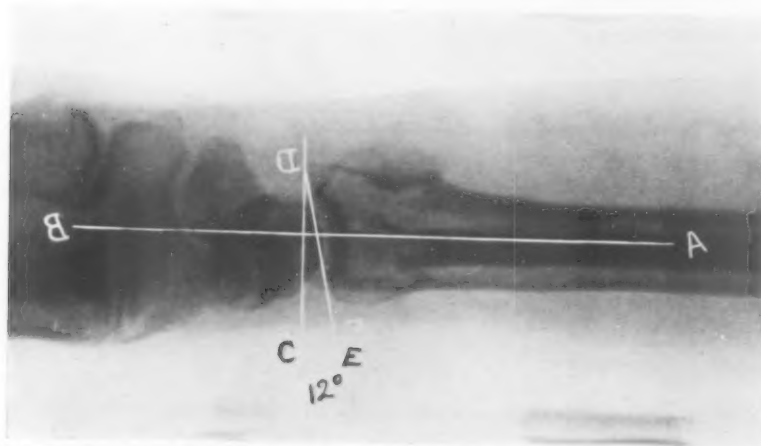


FIG. 3—Showing reversal of angle (so-called impaction). Some of this may be corrected but never all of it, except at risk of a stiffer joint than if it had not been touched. There will be anterior prominence of the wrist in this case unless corrected.

flexion, have all been discussed, and at present it seems to be pretty generally agreed to attribute them to the weaker structure of the flare of the radius at the lower end and let it go at that.

Is Colles' fracture a compression fracture? If it is, then there is no impaction. The general conception is that it is a tension fracture, the break beginning on the anterior surface of the wrist, radius, extending to the back exactly as a dry stick breaks. The man who suffers a Colles' receives it in one way, and one way only.

One writer has said that he has seen a typical Colles' fracture caused by falling on the back of his hand. This is an impossibility and no one ever saw such an injury. The patient slips, throws out his hand to save himself, his hand in pronation, and comes down upon his palm, the hand is forced backward, and the point of resistance falls upon his thenar and hypothenar eminence, the first line of carpal bones, and is transmitted to the radius. If you look at these bones and place them in this position,

you will find that they conform to the arch of a bridge with the semilunar as the keystone of the arch, the semilunar being wedged into the articular surface of the radius, and in this position of pronation the line of resistance will fall nearer the posterior surface of the radius than the anterior. These bones are locked in this position, the elbow is locked also by muscular and ligamentous action, and we have converted the arm and hand into a strut, which at the moment of striking becomes for all practical purposes a column, with a small inclination to be sure, but



FIG. 4.—Shows change in the lateral plane.

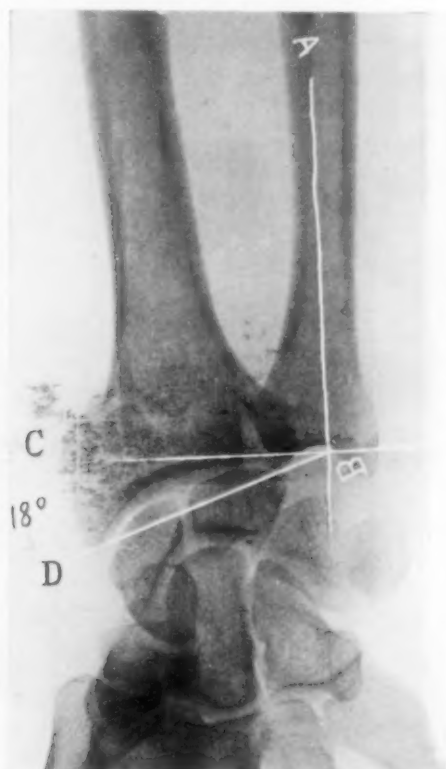


FIG. 5.—Case IV. Lateral view—little disturbance of angle C B D. Antero-posterior view showed, however, reversal of the angle.

pretty nearly prependicular, weight above and the resistance below, and the laws applying to stress in struts and columns apply here.

There are many ways of applying power. By means of the three types of levers and by means of a movable strut, one end of which is fixed firmly and the other moves. This is a powerful way of applying force and is really a lever with one arm gone. It is the principle used in all stone-crushing machines.

The position of the arm in this injury is much the same as the position in injuries to the upper end of the humerus. (See "Fractures of the Upper End of the Humerus," *ANNALS OF SURGERY*, 1918.) Both fall with

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hand in pronation, but the similarity ends there. If the hand and arm are widely extended from the body plane, the moment the hand touches the ground, we get a tremendous lever action, and later on, as the body falls, we get a fulcrum on the acromian process, and a fracture of the upper end of the humerus results.

The difference in Colles is simply one of position. The arm is not widely extended from the body. It is comparatively near the body, and when the hand strikes the ground we have no great amount of leverage. We have a strut action, both ends of the strut more or less rigidly held,



FIG. 6.—Case IV. Motion on tenth day of a Colles.

in reality a column, the weight of the body falling more nearly perpendicular upon the end of the strut or column. It is either straight or bent at the elbow more or less, but held rigidly by muscle action.

In other words, we have really a pile-driver action, the static load of the weight of the man (and pretty nearly his entire weight) coming down upon one end of a column. We have the tremendous increase in stress over the static load due to impact, the weight of the man falling through several feet and landing upon a rigid or comparatively rigid column. It is obviously impossible to estimate this stress in pounds per square inch, because there are so many factors to take into consideration. Some of the force is taken up by the give at the elbow. Some of it is dissipated by the elasticity of the strut or column. Some of it is lost by

the character of the substance upon which he falls, but for purposes of illustration it is a comparatively simple matter to show how tremendously in excess of the strength of the radius such a force would be, and also to determine the comparative ratio of compression to tensile stress. The amount of pounds per square inch are of no importance, since they are enough to smash the bone, but it is of importance to know the comparative stress in compression and tension.

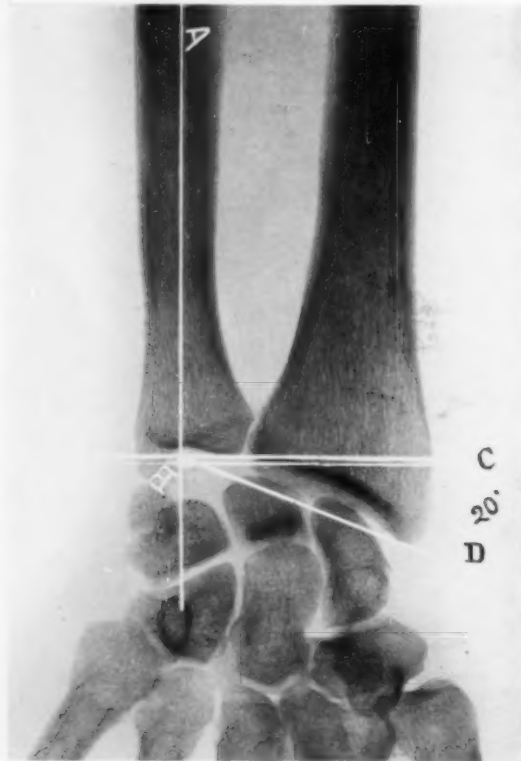


FIG. 7.—Normal lateral plane. Angle C B D usually between  $14^{\circ}$  and  $20^{\circ}$ .

AB, Fig. 17, represents the line of gravity of the load or the neutral centre of the strut, the load in this case being the weight of the man falling through the line of this movable strut AB and striking at B upon the ground. At the instant of striking there is the force of resistance acting along the line CD, in the direction of the arrow, to force the point B upward in the direction of CD, and this we call the bending force. This is what the mechanical engineer terms the line of resistance, and there would be a transverse breaking strain added to the compression force upon the axis of the strut due to the weight of the man falling, and where the lines of these two forces, the resultant acts greatest upon the surface of cortical bone would be the breaking point. There are several reasons, which we shall consider later, why this would probably be the lower end of the radius, but for the present let us consider the compression force alone, along the axis of the strut due to the weight of the man.

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If the movable strut AB, the arm, were rigid and exactly perpendicular, the line of resistance would coincide with the line of gravity, AB, which is also the neutral axis as regards a bending force, and we should not be able to say where the bone would break, after the crushing force, the load, became too great for the strut to bear. But in this case the line of resistance is not the same as the line of gravity, it is the line CD, and somewhere along this line where these two forces act as bending strain, with greatest intensity, will be the point of great com-

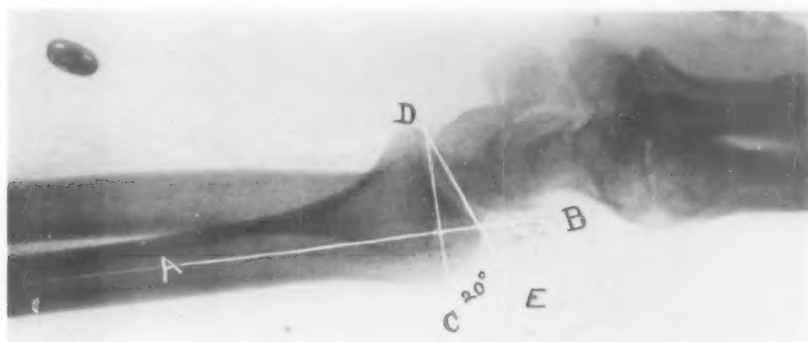


FIG. 8.—Showing normal angle, antero-posterior plane. Line DE is always in front of line DC. Angle CDE seldom less than  $10^{\circ}$  or more than  $20^{\circ}$ . Angle is often reversed in serious cases.

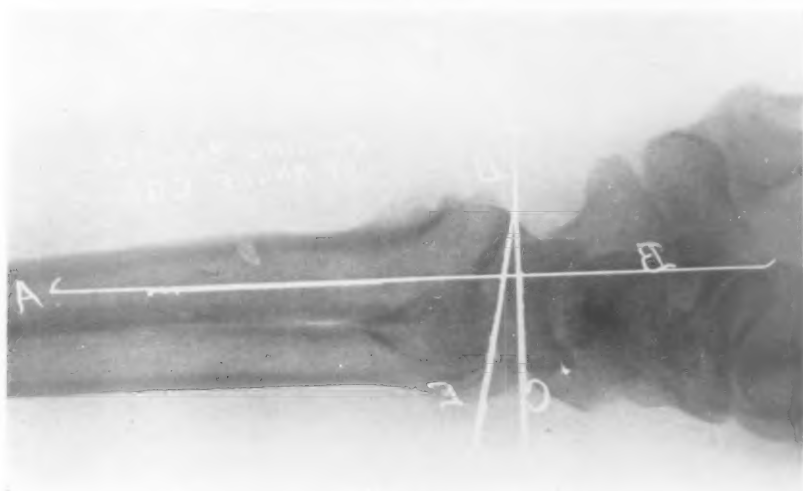


FIG. 9.—Antero-posterior reversal of the angle CDE.

pression, and this is where the radius would break. So exactly opposite will be the point of greatest tension and the radius breaks across EF. The bone may be weaker here as some claim, but weaker or stronger, this is the point of stress, and this is where every radius subjected to this strain will break.

A factor which the mechanical engineer always takes into consideration in computing stresses or strains, is what he calls eccentricity of load, that is where the line of resistance does not correspond to the centre of gravity of his strut, and if you will glance at Fig. 17, you will find that the line DC, resistance, does not correspond with the line of load which is also the line of gravity AB. If we

draw the line GH, from the line of resistance CD, to the line of gravity AB, perpendicular to AB, we have what is known as the lever of eccentricity, and, with this known, we can compute the strain or stress upon our strut, and it is our

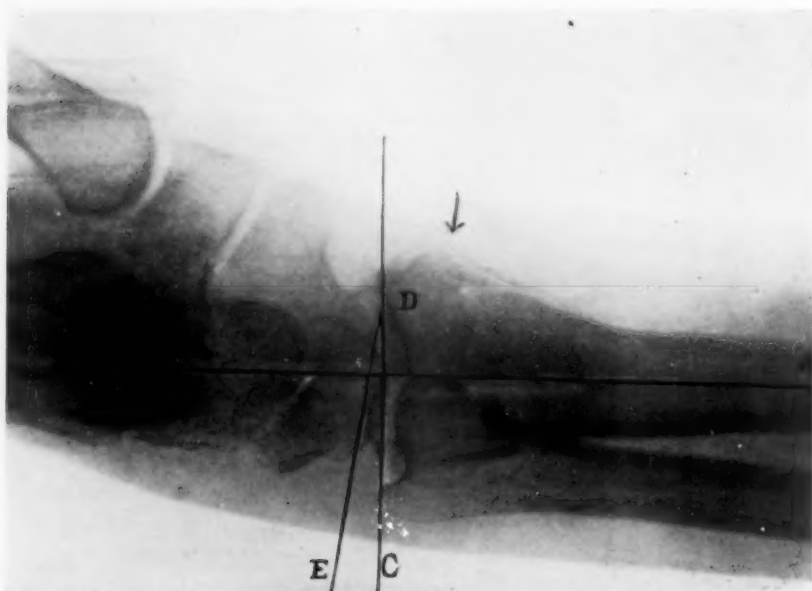


FIG. 10.—Case II. Not true antero-posterior as it should be, angle CDE is in front of CD. Therefore little change.



FIG. 11.—Shows motion active on second day of Type I case. Shows dressing after second day in these simple cases. Same dressing in more serious cases from fifth or sixth day to the ninth or tenth day. Only dressing after tenth day shown in Fig. 12.

contention that this eccentricity of load is more a factor in fracture of this type than the straight compression due to the weight of the man falling on his hand, because it accentuates the compression already existing on the compressed

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side at the expense of the tension which exists upon the other side; in other words, compression is greater than tension. If compression were equal to tension, which is a fact in a simple transverse strain, then it might break in tension as well as compression. Here we have an actual compression, tending to bend the strut, the radius. Is compression greater than tension? Let us see.

Let  $I$  represent the area of bone section at the joint of break,  $\frac{\text{LOAD}}{I}$  equals stress in compression per square inch of section at  $I$ , the point of fracture.



FIG. 12.—Case I. Shows motion—two-exposure plate on tenth day. Restriction here shown is due to our wrist strap. Note ulnar cut-out.



FIG. 13.—Case II. Shows motion on tenth day.

Suppose the area at  $I$  to be a rectangle, it is pretty nearly that any way, with a length of  $1\frac{1}{2}$  inches and a breadth of  $\frac{1}{2}$  inch. Let us assume that the dead load, i.e., the weight of the falling body, to be one hundred pounds. In a heavy man it would easily be that or more, since in this type of fracture the man actually sits down with his full weight upon his hand supported by a rigid forearm. The formula for determining this would be  $100 \div 1.5 \times .5 = 133$  pounds. So that the dead compression on this cross section of bone under these conditions, which are of course simply explanatory, but still somewhat near the truth, would be 133 pounds per square inch of surface. Not such a tremendous force. But there are other factors which come into this problem. The force is not transmitted in the direct centre of gravity, i.e., the neutral axis. With the hand in pronation line of resistance is decidedly

nearer the posterior or upper edge of the bone, and the force of this resistance would not fall in the same line as the neutral line it would fall in the line CD. This, as we have said, is called the eccentricity of load. The line HG is what is called the lever of eccentricity so that after all we have a certain amount of leverage in these breaks. Were this line of resistance exactly along the line of the centre of gravity, we should have no increase in compression over the 133 pounds



FIG. 14.—Case III. After reduction shows some disturbance of the antero-posterior plane remaining.

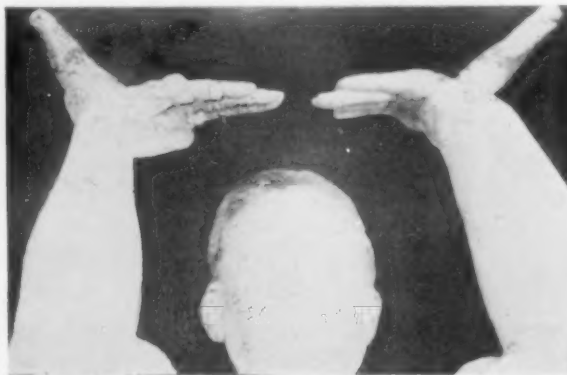


FIG. 15.—Case III. Double-exposure plate to show motion on twelfth day of fracture. Compression fracture of the radius should show ability to approximate a right angle in flexion and at least 45° in extension not later than the twentieth day. Most of them will do this earlier.

of dead compression, up to the bending moment. The bending moment which is represented by load multiplied by HG, the lever of eccentricity, is resisted on the posterior side, top side with hand in pronation, by compression, and on the anterior side, the side nearer the floor, in the case of a man falling upon his hand, by tension, the compression being greatest at the upper edge and the tension being greatest at the lower edge of the bone. This tension of the lower edge is partly offset, we must remember, by the compression due to dead load, which operates here as elsewhere, and therefore, with these facts clearly in mind, let us see what happens at the bending moment.

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This extra compression at H due to eccentricity of load can be reckoned as soon as the section is known. Let us for the purpose of illustration call the section as before.

In Fig. 17, L being the width and K the length of the rectangle, L being  $\frac{1}{2}$  inch and K being  $1\frac{1}{2}$  inches, and let us call the lever of eccentricity, HG,  $\frac{2}{10}$  of an inch. The formula, would then be load multiplied by HG, the lever of eccentricity,  $= \frac{F \times K \times L}{6}$  in which F is the outside fibre strain, cortical strain, and is greater the greater the distance from the neutral axis. Same problem as before, load 100 pounds, section of bone at the breaking point  $1\frac{1}{2}$  by  $\frac{1}{2}$  inch, eccentricity  $\frac{2}{10}$  of an inch. Additional compression due to eccentricity  $100 \times .2 = \frac{F \times 1.5 \times .5 \times .5}{6}$ . F equals 320 pounds per square inch. Total compression then on the upper side of the bone 133 pounds plus 320 lbs. equals 453 pounds per square inch. On the lower side of the bone the tension

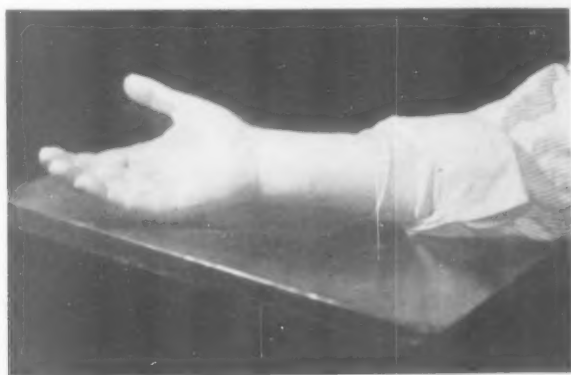


FIG. 16.—Showing how little the deformity even with reversal of the angle; perfectly flexible wrist. Picture thirty-fifth day, so that there is still some of the temporary swelling remaining. Used hand for all purposes after fourteenth day. See Fig. 9 for X-ray.

is equal to the compression due to eccentricity or 320 pounds of tension, but from this must be deducted 133 pounds of dead compression, leaving 187 pounds of tension stress on the under or anterior side of this bone. Compression is greater than tension, therefore, it is a compression fracture; and, therefore, if it is a compression fracture there is no impaction. Nor is this all, for a short column centrally loaded, the compression stress in pounds per square inch equals the crushing weight in pounds divided by the area in square inches, but for a long column which tends to bend under load, the stress on the concave side is greater and on the convex side less than the crushing force divided by the area in square inches. This stress is distributed over the section only when the resultant passes through the centre of gravity. Any deviation from such a centre will bring the maximum unit of stress to one edge and a minimum to the other. We have dealt so far with straight compression, but we must take into account also stresses produced by suddenly applied force, shocks, impact, and these we know are very much greater than dead compression.

Now let us add this also. Merriman, "Mechanics of Material," tenth edition, says that the exact determination of actual stresses in a case of axial impact is impossible by theory where the elastic limit of the material is exceeded. The problem is too complicated, but in our case it is not necessary to know the stress exactly in pounds per square inch. We should have to know the resistance of the material (radius) and the compression produced, and many other factors, but

it is enough for our purposes to know that the stresses produced are tremendously greater than the static load. Merriman, page 327, tenth edition, cites an example of a stress produced by a load of 60 pounds, moving at a velocity of 10 ft.

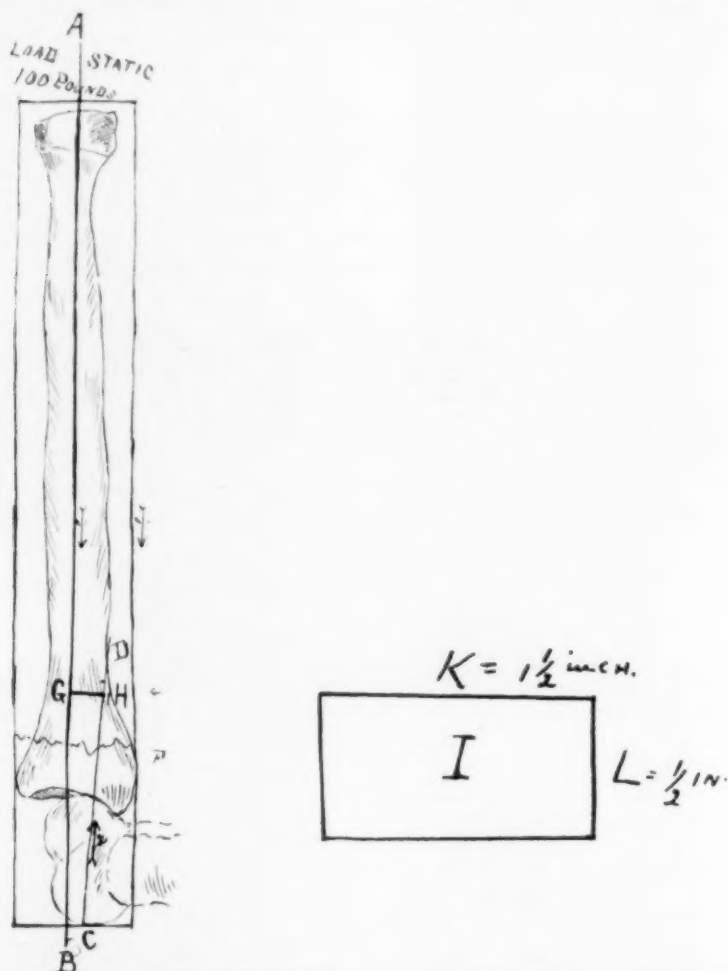


FIG. 17.—A B, strut. B being the immovable end of the strut, friction on the floor or ground fixes this end firmly. Should it be very slippery and not hold, he will not break his wrist. It is conceivable that under these conditions he may break his shoulder, as I have shown in another article (see "Fracture of the Upper End of the Humerus," ANNALS OF SURGERY, 1918), but he will not break his wrist. I, rectangle representing lower section of radius; K, 1.5 inches for purposes of computation; L, .5 inch.

NOTE.—In Fig. 17 and in this article we speak of the centre of gravity of the column. Were the column perpendicular the centre of gravity and the centre of compression would be the same and they would also be the neutral axis. In our case, however, the column is inclined and the centre of gravity would in reality not be the same, as the centre of compression or the neutral axis. In using the terms "centre of gravity" in our case it is understood that it is the centre of compression which we mean and not the exact centre of gravity which is the term that the mechanical engineer uses in estimating stresses on a perpendicular column. The centre of compression in this case as in the perpendicular is of course also the neutral axis.

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per second and producing 510 times as great a stress as was produced by the same load as static load. Now, we know, if our man fell from a height of 3 feet without resistance, he would be falling at the end of the 3-foot fall at about 14 feet per second. Imagine what the force of the blow would be expended on our radius of  $1\frac{1}{2}$  by  $\frac{1}{2}$  inches. And remember that no matter what the blow would be it would act eccentrically exactly as the static load acted, and the compression force would be increased always over the tension, in the same proportion which we have already shown as static load. Multiplying our figures by 10 even, and the result would be 4530 pounds per square inch of compression against 1870 pounds of tension.

So that, apparently, in the case of a man falling upon his hand, and therefore offering the resistance of friction to the sliding, we have added the increased stress of a sudden blow which is immensely greater. We have also in this case the eccentricity of load, due to the line of resistance not passing through the neutral axis of the strut, thus increasing the compression force on the side of compression and diminishing it proportionately on the side of tension.

We have the bending force, since the strut in this case is long in comparison with its area in square inches in section, and we have the molecular inertia of material in the presence of a blow greater than its compressive or tensile strength, this blow falling on the lower end of the strut, the radius.

We know it breaks at this point, which therefore must be the resultant of the breaking stresses which have been brought to bear upon the bone. Why should it always break at identically the same point? As a matter of fact, it probably would not save for two factors, velocity of stress and inertia of the material. Our strut is more or less fixed at both ends and resists motion, as we have said.

Now velocity of stress is exactly the same as velocity in anything else, depending upon a great many factors, of course, and where this stress or strain is markedly out of proportion to the strength of the strut, the first section of the strut receiving this impact would be unable to transmit it along the whole strut, therefore, the section first subjected to strain would be the part to break, in our case the lower end of the radius. We must also take into account the molecular inertia of material, and here again, where the strain is so much greater than the strength of the strut, the tendency would be to break at or near the first contact and this again would be in our case the lower expanded end of the radius.

We may add to this, if we wish, a point which has always been claimed but never proved, that the lower expanded end of the radius is the weakest part of the bone. That is still *subjudice*. The main point of all this, which may seem to some needless, is that the bone breaks in compression and not in flexion, primarily, and that if this be so, we get an entirely different kind of a break as regards the fibre structure, a compression break on the posterior side of the bone, just above the wrist-joint, always at or near the same point, and a tension continuation across

the anterior surface. It does not fissure behind; it may or may not fissure in front.

In certain cases we may have an added torsional stress, at the same moment. The difference of deformity, even of the plane of break, will depend upon the relations of the radius to the blow struck. Should the hand be flat in pronation the break is directly above the joint and the distal fragment goes backward into posterior angularity, tilt. If the blow falls upon the ulnar side of the hand the direction of the line of resistance is again different, there is a different area of compression, and on breaking the distal fragment is abducted and posterially displaced as well, but the abduction deformity is greatest. The normal planes of the joint are changed, not due to impaction, as has been claimed, but due to actual compressive destruction of cortical bone, and this is the reason why these planes can not be entirely replaced in their normal relations. This change may be little or it may be great, but it is always there, and it remains under any form of replacement. By weight extension and fixation until new bone filled the gap it might be corrected, but it would be by holding it in position for a long period of time, and the result so far as motion is concerned would be far more apt to be unsatisfactory. After all, the great desideratum is a freely movable joint at the wrist.

The eye is fallible even in judging an X-ray plate and the main point to determine is the change of plane both antero-posteriorly and laterally in these compression fractures, because an anatomical replacement, as far as possible, is to be desired, especially in an area which is so crowded with important structures.

A two-way X-ray in these cases, exact antero-posterior and exact lateral, is a necessity, but it is usually not possible to have these taken until after reduction. In hospital cases this can be done, as it does not entail any great degree of lost time, but the rule reduce at once, is by far the better rule. The sooner the reduction the less reaction to injury. The stereoscopic view is of little use in this type of fracture. A stereoscope is valuable to show rotation, and no rotation or very little is possible in the ordinary Colles. Some writers speak of rotation of the fragment. Rotation of a long bone is a twist upon its long axis and a twist upon its long axis is an impossibility in an ordinary Colles. What these writers mean is backward displacement. The X-ray tells us two things which are important. Are the two planes of the wrist-joint, lateral and antero-posterior, restored so as to approximate normal? It is difficult to measure this with absolute certainty, because there is no fixed point from which to start that under all conditions and positions of the hand remains the same. Obviously it could not be measured in centimetres, the distance from the tube at which the X-ray was taken, the difference in the size of the bones in different cases, would render worthless any such scheme of measurement. We have depended upon angles and these must of necessity vary widely, but we think that they approximate closely enough, so

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that we are able to get a fair idea. If the lateral plane is not restored it is quite obvious that the entire hand will be thrown toward the thumb side, abducted, the ulna will be unduly prominent, and if the antero-posterior plane is not restored it is equally obvious that a certain amount of backward displacement of the hand will remain and the anterior curve of the wrist will be exaggerated. The ulna is usually not broken. Draw a line as nearly in the longitudinal centre as possible. It will never be exactly the same, but for practical purposes it will answer (see A B, Figs. 4, 5 and 7).

At its lower end, where it cuts the lower surface of the ulna, erect a perpendicular to AB. It will cut through the enlargement of the lower end of the radius. Do not measure from the ulnar styloid, it is too often broken. BC is this line. From B draw a line to the lower inner side of the radial styloid, BD. In a great majority this angle will be found to be between 14 and 20 degrees and it will not vary greatly from this. Should there be much change in the plane of the articular surface it will show in the reading of this angle, and with this help it will be much easier to predict the subsequent amount of deviation. The nearer the line DB comes to CB the greater change in the lateral plane of the joint, and the smaller the angle. It is better to be forearmed and to have a definite idea of what is coming in the way of permanent deformity than to have the patient discover this later for himself. A thing explained beforehand and understood by the patient may save a lot of trouble later. It is better to have good function than good looks where one has to be sacrificed for the other.

Usually it will be possible to conserve both but where there is any question sacrifice looks always to function. Of even greater importance will be the measurement of the antero-posterior plane of the joint surface. This must be a true lateral view, without distortion. Draw a line straight down the centre of the radius, ignoring the broken end, AB (Fig. 8). Join this line by another perpendicular to AB just touching the anterior inferior surface of the radius CD. Draw the line DE from D just touching the posterior extremity of the radius at E. The angle CDE will nearly always be an angle of between 10 and 20 degrees. It will rarely be less than ten and equally rarely more than 20 but the angle will always be in front of CD, the posterior side of the radius being always this much nearer the hand than the anterior. When it approaches 10 degrees in a broken radius there is suspicion of a change of plane antero posterior, and many times it will show obliteration or even reversal of the angle (Figs. 3, 9, 10). If impossible of correction, it will mean a certain prominence always of the wrist and a backward tendency to the hand. It is up to the individual operator whether he will attempt to correct this tendency or whether he will not do so, but at any rate he will thus be able to recognize the condition and be prepared to explain it satisfactorily to his patient. It is surprising how little deformity persists sometimes even when the destruction has been sufficient to reverse the normal angle at the joint. Fig. 9 shows this reversal of the angle, and Fig. 16 shows how little deformity with a perfectly movable hand resulted from this apparent great change of plane. This is the real explanation of these cases of abnormal prominence which persist rather than the loosening up of the flexor tendon sheaths from their attachment to the bone, to which it has often been ascribed.

CLASSIFICATIONS. First.—*Simple transverse fracture* of the bone with little or no evidence of compression. These are more often the automobile fractures. The mechanics of the fracture are the same, but the force is

not great enough, except in rare instances, to badly damage the structure.

Second.—*Fracture of the lower end of the radius with evidence of great compressive force.* There is here actual loss of substance on the posterior surface of the bone, so-called impaction. Flexion, cracks, or fissures may or may not exist on the opposite side. The planes of the articulation are always changed, much or little.

Third.—*Fractures of the lower end of the radius with displacement of the distal fragment backward and sometimes in abduction.* Often there is impingement of this fragment on the posterior sharp surface of the proximal fragment, the so-called rotation of the fragment. The same injury oftentimes breaks the styloid of the ulna or even the ulnar shaft, but the ulnar break is always secondary to the main break and not a compression break.

The break of the ulnar styloid is simply a sheering fracture. The break in the radius lets the ulna down so that the styloid meets resistance and is sheered off.

The ulnar fracture higher up in a simple transverse tension breaks as the resultant of two forces, secondary to the main break. The man falls forward, his arm bent at the elbow. The muscles of his arm are resisting the fall and trying to straighten the elbow. The force below on the end of the ulna is acting also to bend it. Result, a transverse tension break of the ulna.

If continued the force may push the ulnar shaft through the skin, but these do not form a special type. There are only three types and all fractures of the lower end of the bone fall readily into these three different forms. Whether the ulnar styloid is broken or not is unimportant. If the ulna above has been broken we have a different problem, but a different problem only as regards treatment. Let us go further with this inquiry, since the fracture of the bone is not the only thing which happens, and is, in fact, barring disturbance of planes, one of the least important. The wrist is a compact structure. Running through this restricted area, both front and back, are many tendons with their tendon sheaths and slips of connective tissue binding them closely to the bone, blood-vessels, nerves and ligaments. The position of the hand as the patient falls relaxes all the extensor tendons at the back of the wrist and correspondingly tenses all the flexors. The flexor tendons, especially at the bending moment, are under a tremendous strain, and as the bone breaks or even before, the connective tissue slips which tie these tendon sheaths to the bones are damaged, torn loose. These flexor sheaths and flexor tendons, following strain, react to injury, and we have effusion into the tendon sheaths and more or less bleeding.

If now the distal fragment is dislocated we may have further injury to the flexors, particularly the flexor carpi radialis, because of its insertion nearer the break and consequently greater tension, by the sharp anterior surface of the proximal fragment. The extensor tendons are

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not in tension, the wrist is hyperextended, the weight of the load plus the tension of all the flexor tendons forces the fragment backwards. The fragment tilts and the sharp posterior edge of the proximal fragment locks it, impingement. The extensors and abductors of the thumb and the radial nerve may be injured by the sharp posterior edge of the distal fragment as it goes backward into dislocation, but usually the injury is not severe. The extensor carpi radialis longior and the extensor carpi radialis brevior, because of their insertion comparatively near the fracture, are now tensed across the distal fragment. The extensor longus pollicis, because of the same reason and its short length and oblique position, with reference to the distal fragment, is also under tension. The terminal phalanx of the thumb is extended and it is difficult to flex this phalanx. The thumb can be approximated to the palm, but the terminal phalanx of the thumb remains extended and this extension is a good point to remember as gauging the accomplishment of a good reduction, because the moment the lower fragment is reduced the terminal phalanx of the thumb can be flexed. The extensor longus pollicis is restored to its normal condition and the tension is removed.

In the abduction Colles, the deformity is even more pronounced than in the posterior displacement, because here you usually have a combination of posterior and abduction deformity, but once reduced, even the obliquity of the fracture, if such exist, is not a tremendously serious drawback, because if one considers the normal anatomy of the wrist-joint he will find that only two muscles are attached to the fragment, the supinator longus or brachio radialis, and the pronator quadratus, one supinator and one pronator, and once reduced the fragments are splinted anatomically behind by the extensor communis digitorum, externally and posteriorly by the extensor carpi radialis longior and brevior and the extensor longus pollicis tendons to prevent backward displacement, and how better could one prevent abduction deformity from recurring than the presence of the extensor ossis metacarpi pollicis and the extensor brevis pollicis, which are practically splints over the external aspect of the joint.

The only fly in the ointment, as it were, is the pull of the supinator longus attached to the lower external surface of the humerus and inserted into the very tip of the styloid process, which does tend both to produce and to perpetuate the flattening of the lateral plane of the joint by tending to abduct this distal fragment.

Adduction is the only remedy which we have and restriction for a few days of the action of the supinator longus by splints and bandaging. This is why we leave abduction movement to the last and is the most important reason for splinting. In front are the flexor carpi radialis, the flexor longus pollicis, and the long flexors, and, as a splint is of use only to prevent recurrence of deformity, principally by limiting muscular action, what better splinting could be imagined than by this large number of tendons playing across the broken surface?

Reduction is the first consideration and, of course, comes before there is any necessity for the determination of planes, but it has seemed better to us, for the purposes of this article, to discuss the question of planes before taking up the reduction, because we can do so much to correct this disturbance if we have a clear conception of what has happened and of the mechanical problem before us. There has been no improvement in the old method of reduction of a Colles fracture, hyperextension of the hand, local pressure downward on the distal fragment, strong flexion, and stronger adduction with local pressure. Circumduction is never necessary. The ulnar styloid is not entangled in the torn ligament. The soft tissue may fall somewhat between bony fragments wherever there is a break, but circumduction is an unnecessary manoeuvre. With the thumb extended strongly the extensor longus pollicis is relaxed, with the hand hyperextended strongly, the extensor carpi radialis longior, the extensor carpi radialis brevior, and the long extensors are also relaxed. The flexors are under no particular degree of tension except possibly the flexor carpi ulnaris, and this only when there is a forward dislocation of the ulna, and, therefore, need not be considered. In hyperextension the fragment moves freely because released from its bow-string retainers, and with the thumb can be pushed forward easily. As the hand is swung downward into flexion and strong adduction at the same time, the bones slip into place and are held firmly by the tendons. Adduct strongly with local pressure to correct the lateral plane as much as possible. Without this manoeuvre of hyperextension one cannot move these broken radii. Why? Because the distal fragment is tilted backward and five bow-strings are thrown across it under tension, the common extensor, the extensor indicis, the extensor longus pollicis, the extensor carpi radialis longior, and the extensor carpi radialis brevior, and combined they are strong enough to resist a tremendous amount of pull. There is usually an effusion into the tendon sheaths which shows pronouncedly over the common extensor and the extensor longus pollicis, where displacement has taken place, and this may and does persist for a long time. It also accounts for the pain on the back of the hand from the pressure of a hard posterior splint. This exudate also exists in the flexor sheaths and to a greater extent, since they are usually more traumatized by stress, and this accounts for some of the temporary prominence of the front of the wrist at this time. We will assume that reduction has been effected, the important parts of which are as we have said, hyperextension unlocking the fragment from its bow-string retainers and from its impingement, sharp flexion and adduction of the hand with local pressure added to reduce the posterior and abduction deformity. Flexion and extension are now possible and free. Try them, actively, but do not abduct. The main point which one wishes to know about every Colles once the reduction is effected is the damage to tendons and nerves. One can rest one's mind easy about the bones slipping out of place. Lay the arm

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extensor side downward upon a flat surface. Can he flex the terminal phalanx of his thumb and extend his thumb at the same time? The extensor longus pollicis tendon is free of tension and the posterior displacement of the distal fragment must be, therefore, reduced. Can he approximate the thumb and little finger? The deep branch of the ulnar has escaped injury. The superficial branch of the ulnar is entirely sensory and is given off below the wrist, but if it were injured, there would be anæsthesia of the little finger and inner side of the ring finger and inner side of the hand. In injury of the ulnar nerve at the wrist there is no weakness of the flexors, but the interossei and hypothenar muscles are affected and also the adductor obliquus and transversus pollicis, and the short head of the flexor brevis pollicis. The fingers cannot be spread widely apart. This is a movement by the interossei, and all the interossei, palmar and dorsal, are innervated by the deep branch of the ulnar nerve. If the median nerve is injured at this level, there is a paralysis of the short flexor and abductor muscles of the thumb and the two outer lumbricales. The index and middle finger can be flexed by the action of the long flexors, but the first phalanx cannot be flexed while the middle and terminal phalanges are kept extended. This movement is done by the lumbricales, and the two outer lumbricales are innervated by the median. It will also be difficult for him to approximate his thumb and index finger because of paralysis of the short flexors of the thumb, but the lumbrical action is decidedly a better guide because of the ulnar innervation of some of the short thumb muscles. There will be anæsthesia of the palmar surface of the thumb, two outer and half the ring fingers. If the radial is injured do not look for the classical anæsthesia following the anatomical distribution of this nerve, extensor surface of the thumb, index, and middle fingers. You will rarely, if ever, find it. It is more likely that a small area of anæsthesia will be found on the back of the hand between the thumb and index finger. The nerve is sensory and no muscle paralysis follows. Have any of the long flexors or extensors of the wrist been injured or ruptured? He flexes his hand at the wrist. Let him do so gently; the fragments will not come out of place. His flexors are intact. Let him extend his hand, but not beyond the horizontal plane. The extensors are intact. Let him adduct his hand; the flexor carpi ulnaris and the extensor carpi ulnaris are intact. The thumb extensor is the one most apt to be injured. Flex and extend the thumb. It is intact. Do not abduct at all; do not pronate or supinate. These are the only motions which he should not do. In nine cases out of ten it would do no harm if he did, but there is no need of taking chances on the tenth case. The patient with a reduced Colles should be able immediately to move the wrist and fingers sufficiently to demonstrate these facts. We now apply our splints, and once the reduction is effected almost any old splint will answer the purpose. In other words, it is not the splint which is important, they are put on simply to put the muscles at rest. Theo-

retically a bad Colles should be put up with flexion at the wrist, strong adduction, and the hand carried in the position of supination, to relax the supinator longus muscle, but practically it is not necessary, and not comfortable. Personally, we use an anterior and posterior splint with ulnar and thenar cut-outs angled at the wrist in adduction thirty degrees, in bad cases. In mild cases the straight splint is good enough. The Walker is a good anterior splint, but not so convenient for the after treatment which we use.

If all patients were intelligent and had a good understanding of the mechanics of Colles' fracture, nothing but a wrist strap of leather would be required in any of these cases other than the abduction Colles or the one with comminution of the bone. But a splint is of value for impressing upon the mind of the patient the fact that he has a broken wrist. He can never forget it, even for a moment, and this is its greatest advantage. We must use a splint with a large ulnar cut out. Most of these ulnar cut-outs are too small. A strip of board along the posterior surface of the radius would be just as good without including the ulna at all. This permits the ulna to be pressed backward into its proper place, and the tendency is rather to push it forward. The position of the ulna is decidedly posterior and when this is not taken into account in these cases with ulna dislocation, the ulnar prominence is afterwards lost. This posterior splint should never go below midway of the metacarpal bones, leaving all the extensors of the fingers free, an angled board for the anterior splint with cut-out for the thenar eminence. The thumb must be free. In cases where no displacement has taken place, a simple two-inch by two-inch board across the wrist for the anterior splint is sufficient, but here, again, the long anterior splint is of advantage for the first few days simply to impress the patient. If the fracture is satisfactory as shown by the X-ray, the patient is dismissed for twenty-four hours. If the splints are not too tight, he will seldom suffer a great deal of pain, but in certain neurotic types one should expect a certain amount of discomfort. The majority are perfectly comfortable.

The thumb and fingers are used actively from the first. The patient is instructed to approximate the thumb to all the fingers a dozen or more times a day and to flex and extend his fingers and thumb whenever he thinks of it. The thumb is the one digit most likely to show a slight restriction in motion and some numbness which passes within the next few days. Twelve to twenty-four hours afterwards the anterior splint is removed and passive motion begun at the wrist very gently. I usually leave the posterior splint on during this passive motion for the first few days and with my left hand across the radius prevent abduction movements of the hand by pressure over the insertion of the brachioradialis muscle. The thumb is flexed and extended, the hand is flexed on the wrist, but not extended on the first day beyond the posterior splint. There is no pain in these manipulations. If the fracture is a simple type

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one case, I begin active motion at the wrist on this first day, permitting him to flex and extend his wrist, to move his thumb and fingers and to approximate the same, to try the adduction movement where there is no broken ulnar styloid, but not to abduct (Fig. 12). In this class one type I know that I might safely substitute a plain leather wrist strap on this day without fear if I cared to do so, and in some intelligent patients I have so done. There is, however, nothing to be accomplished by this, because by the time that one is willing to turn these cases out free from restriction, their wrists are flexible, and if we do not gain time it is certainly not advisable. The point of the entire treatment is motion quickly. In the more serious cases motion is given the joint every day for ten to fifteen minutes passively, and on the third or fourth day active motions are substituted for passive. In fact, in the majority of these cases, active motions are begun on the second day. Abduction motions are usually left until after seven or eight days. If the case is a simple automobile injury without displacement, at the second or third dressing the posterior splint is cut to a strip about one and one-half inches wide along the posterior border of the radius with a two-by-two piece of board well padded anteriorly, the padding being especially thick over the ulna in order to press it backwards (Fig. 11). The posterior splint in this second dressing extends slightly below the wrist-joint in order to limit extension and only a short distance above the fracture. This allows for a certain degree of motion at the wrist which is desirable. The arm is still carried in a sling, a narrow one, not one which encircles the whole forearm. By the sixth day all anterior splints are off, save plaster strapping, and by the ninth day all splints are off except a wrist strip of leather with an ulnar cut-out, which is worn from this time on (Fig. 12). How long a patient wears this is a matter for himself to decide. Some of them like the feeling of it and wear it for some time. Be sure not to buckle it too tightly. Be sure the ulnar cut-out is large enough. If there is comminution of fragments, if there is an abduction Colles with tendency to displacement of the distal fragment on account of an oblique fracture, do not go so fast, but even in these cases by the tenth or twelfth day all danger of dislocation will have passed under ordinary care. In these cases it is well to wear splints longer and to institute active motion later, but one should not wait too long even here. A stiff wrist is not a comfort to its possessor, and one that begins to stiffen is hard to loosen up. It is easier to prevent this than to recover the motion after it has been lost. This applies to all joint fractures. Do not permit the joints to stiffen in the first place. This can be accomplished by early active and passive motion in every case. In a region which is so crowded with tendons and important structures as the wrist, an injury to this region is always a serious matter, and as these cases are handled to-day a simple automobile crack seems to be quite as serious to the patient as a more serious break with displacement. The joint is locked up, is looked at

occasionally, and after three or four or even five weeks is worked, baked, massaged, etc. The patient is out of commission three, four, or five months, and many of them I have seen out of commission for over a year. None of them recover their motion for a long time, and some of them do not recover full motion at all. Deformity does not seem to influence the result so far as motion is concerned to the degree one would expect. A wrist without deformity often shows restriction of motion, while a badly replaced one shows practically a normal wrist motion. This is in line with my contention, first, that there is a traumatic arthritis of the joint with effusion into the joint. Lock this up and it will be stiff no matter what you do. Second, the tendons, flexors, and sometimes the extensors are traumatized, their attachment to the bone is torn, their bursa are filled with inflammatory reaction products. The subcutaneous connective tissue structures are traumatized and infiltrated with leucocytes. The anterior radiocarpal ligaments may be torn, the posterior never, but I have purposely avoided mentioning them specifically. Their importance has been overestimated. They belong only in the concomitant injuries of soft tissue. They play no major part either in the mechanics of the production of these fractures, their reduction, or their treatment. I know that I am controverting many pet theories, but I believe that they simply belong in the class of the generally injured soft structures. Of vastly more importance is the ruptured inferior radio-ulnar ligament, widening the joint by ulnar separation, and this feature is adequately cared for by forcing the ulnar sufficiently backward. Leave this mass alone, rigid, to organize and bind down tendons and wrist structures and then expect motion? Is it rational? We might just as well open the wrist, turn in a quantity of glue or plaster of Paris, if it could be done, and then expect the joint to functionate. By early gentle motion we free these tendons, prevent adhesions, limit the degree of scar formation, and get a functioning joint early. After all, does it work out? I have space here for only a few illustrations, but I have many more cases which I could use. Four will be sufficient, since they are all fractures which show the compression feature which is the important feature of the bony injury, is always present in bad cases, and cannot be overcome entirely by reduction. It could be entirely taken care of, but at the expense of wrist motion.

CASE I (Fig. 12).—Man, aged thirty-five years. Compression fracture of the lower end of the radius. Type II. Broken ulnar styloid. Planes restored. Active motion second day. Splints off tenth day. Painted a picture on the seventeenth day. Drove a horse race on the nineteenth day of the injury, but not with our permission. This represents the main danger of this treatment, carelessness of the patient. No harm resulted.

CASE II (Figs. 10 and 13).—Mrs. D., aged sixty-eight years. Compression injury. Lower end of the radius. Concomitant injury;

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broken fragment of the external condyle of humerus. Discharged the nineteenth day. No subsequent trouble.

CASE III.—T. P., man. Fig. 14 shows X-ray after reduction. Planes good. Fig. 15 shows motion twelfth day. Sailed for Europe on the nineteenth day. Some little tenderness over the ulna persisted for some weeks. Motions good. Used hands for all purposes after the fourteenth day.

CASE IV (Fig. 5).—S. T., man. Active working second day. Anterior splint off fourth day. Fig. 6 shows motion on tenth day. Discharged twentieth day. X-ray shows disturbance of the antero-posterior plane not so pronounced as Fig. 3. Result satisfactory.

Will there be cases of traumatic arthritis, those cases which show good motion at first and later lose it, the thing which every surgeon fears? Of course, there will be as there has been in the past, but not on account of the treatment, and in no greater or as great numbers as before. We had some of them under the old treatment; we shall have some under the new.

*Résumé.*—The treatment of Colles' fractures, or, as I term them, compression fractures of the radius, as dealt with at present and as handled in most of the larger hospitals of the country, save for a few individual members of the medical profession, belongs to the mediæval era when men discussed the important question of how many angels could dance on the point of a needle. In fact, the whole subject of joint fractures and joint injuries must be taken up and worked out on the basis of results obtained rather than upon the basis of what some one man who is supposed to know thinks. We have too long accepted as final some one man's judgment of what is and is not the correct thing to do in certain pathological conditions, and have found out later on that he was fallible like the rest of us.

Colles' fracture and, in fact, all joint fractures, are to-day upon a different plane than ever before. War and the compensation acts of various states have made it a commercial proposition, and it has become a serious necessity to turn back these cases of joint injury into their respective channels of productivity as soon as possible. In other words, it is a factor to be considered in the ordinary overhead of the commercial world. It costs money, and that cost is to-day apportioned to the industry to which injured men belong and, therefore, competition is the driving force to compel efficiency. Colles' fracture certainly contributes to the overhead expenses of corporations, insurance companies, and individuals in this country probably as much or more than any one fracture. Stimson said years ago, a statement which he could make with equal truth to-day, that there were more Colles' fractures with bad results than any other type of fracture, and he added to his statement that he had seen more bad results from treatment in the great metropolitan hospitals than anywhere else. The burden of expense caused by this one fracture, the

loss of time, the loss of wages, the loss of productivity is enormous. The treatment of these fractures one hundred years ago would not make a bad comparison with the treatment which is generally in vogue to-day. It makes a vast difference to the economic scheme of existence whether the thousands of Colles' fractures which are happening in this country every day are invalidated from three to six months, as they are, or whether they are returned to work within a reasonable length of time, and nine out of ten Colles can be returned to light work within twenty days with advantage to the country's economic condition, and equal advantage to the man who has the Colles. When we begin to compute the actual saving the figures are simply astonishing, and if this country of ours is to go ahead, is to exist even, after the present fandango of high prices for employers and employees and trades people has passed, it will be more than ever necessary to eliminate the waste. We are facing a competition which is coming that will make us think that in our pre-war days we had none. The treatment of Colles' fracture as responsible for economic waste would be a good subject for investigation.

#### SUMMARY

1. Fractures of the lower end of the radius (so-called Colles) are always compression fractures, the compressive side breaking first, literally collapsing.

The first point of fracture is the point of greatest compression upon the cortical surface of the bone because the stress increases both in compression and tension the further away from the neutral axis.

2. It breaks in compression because the compression is much greater than the tension. Green bone reacts to strain like wet timber. It breaks at the lower end of the radius because there are several forces, and the resultant is on the lower end of the radius posteriorly. This is due to direct compression from above, the hammer blow from below, the resistance both to compression and to blow being not in the centre of gravity, but eccentric to it and, therefore, increasing the strain. It is also due in part to the velocity of stress and the molecular inertia of material.

3. These compressive fractures of the lower end of the radius show the evidence of compression. There is actual loss of substance, but no impaction. Breaking up the impaction (so-called) cannot restore the planes of the articulation, nor does it do so.

It might be possible by traction over a long period of time to separate this crushed surface and permit its being filled in by new bone, thus restoring the planes of the articulation, but to do this would be to sacrifice some of our chances of securing a freely movable wrist-joint.

4. Early reduction followed by early passive and active motion will return all or nearly all compressive fractures of the radius to useful light occupation within twenty days. Any retentive apparatus other than a leather wrist strap after ten to twelve days is contraindicated except in a very rare instance.

## PSEUDOMYXOMA PERITONEI \*

WITH REPORT OF SIX CASES

By MONTGOMERY H. BIGGS, M.D.

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FIRST described by Werth, in 1884, pseudomyxoma peritonei has received but scant mention in the English language and few cases have been reported by American writers. A general review of the literature, however, shows that its recognition is becoming more frequent.

I operated on my first case in 1907, and was able to keep this patient under observation until her death in 1916. The nature of the condition was recognized and a confirmatory pathological report secured. Since that time I have operated on five other cases in which microscopic examinations have been made, and one case, not included in this series, in which the specimen was lost, but clinically there was no doubt as to the diagnosis. All specimens have been examined in the Laboratory of Gynæcology of the University of Pennsylvania, pathological reports having been made in the first case by Dr. B. M. Anspach, and in the other five cases by Dr. C. C. Norris. Only a few weeks ago my colleague, Dr. Henry Norris, operated for this condition and the patient has made a most satisfactory recovery.

Pseudomyxoma peritonei may be described as an inflammation or irritation of the peritoneum, caused by the discharge of the epithelial lining and the contents of a pseudomyxomatous cyst of the ovary or appendix, and resulting in the production of pseudomucin and secondary tumor formation.

The pathology of this condition, even to-day, is ill-defined, but in some of its phases it is particularly interesting. Quoting from the original paper by Werth: "The gelatinous contents of the cyst contain chemical substances which are not soluble in water and cannot, therefore, be absorbed by the peritoneum. Even if the peritoneum could absorb these substances they could not be carried in the lymph channels because these spaces would become obstructed. Therefore, these remain and travel into all parts of the peritoneal cavity on account of the peristaltic activity of the intestine. They act as foreign bodies on the serosa and stimulate the formation of new vessels and connective tissue."

In contradistinction to this original view of Werth; Olshausen, Pfannenstiel and others believe that the process is an implantation metastasis from a primary ovarian tumor; while Fraenkel states that the metastases are not complications but are part of the original process.

In a contribution to the subject by Goldschmid, he states that gynæcol-

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ogists have held that it was a true metastasis from displacement of epithelial cells, with new growth of mucous masses; while anatomists have held that it was merely the organization of mucous masses from the tumor.

To my mind the most tenable theory as to etiology is that of cellular implantation: the epithelial cells lining the cyst, together with the pseudomucinous content of the cyst, being discharged through a rupture of the cyst wall into the peritoneal cavity, the cells there functioning as they did in their original situation.

We must attempt to explain the rupture of pseudomucinous cysts without the production of pseudomyxoma. That this frequently happens cannot be doubted. Rupture of the ovarian cyst usually occurs in the larger loculi, which are distended, the walls are thinned, and the point of rupture is lined by partially degenerated or comparatively inactive epithelial cells. Few cells are apt to be discharged with the pseudomucin, and these cells are not good plants. Further, as a rule, the loculi in which the fluid is not under much tension are lined by columnar epithelial cells that are very active. These cells usually appear to be rather firmly attached to their basement membrane and are not easily displaced, so that even if the smaller loculi are ruptured, few if any epithelial cells may escape. These facts probably account for the comparative rarity with which pseudomyxoma develops, even when there has been rupture and sufficient time has elapsed prior to operation or death to allow for growth. Active cells are not the rule in the appendix but are almost constant in pseudomyxomatous cysts of both the appendix and ovary, and they are often loaded with pseudomucin. When they are discharged in larger number than can be resisted or destroyed by the peritoneum, they become attached, grow, function, and cause pseudomyxoma. A close study of cases will show that the new growth follows the primary form in histologic characteristics and produces the same type of material.

At first this condition was considered, in every instance, to be the sequel to a previously existing ovarian cyst, but it remained for Fraenkel, in 1901, to observe that the appendix may be the seat of the primary pathology. In numerous reported cases in which both an ovary and the appendix were the seats of this condition, it has been demonstrated that they were independent in origin. In my series the appendix was affected in three cases, of which two showed transplants, and in one it was the seat of a mucocele. Secondary involvement of the appendix is not remarkable, as any organ covered by peritoneum can be attacked.

I would say that pseudomyxoma has no distinctive symptomatology, except when the lesions are advanced and widespread. The symptoms manifested are usually those due to mechanical interference with function and may be caused by blocking or closure of the lymph spaces, cutting off of the blood supply, thickening of the peritoneal covering of organs, resulting in tumor formation on their surfaces and encroaching on func-

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tionating tissue. Constriction of the intestine is not uncommon. Early cases will be discovered at operation; late cases presenting effusion with irregular, firm tumor formations distributed throughout the abdominal cavity can be diagnosed pre-operatively.

The early history of these cases can yield but little information other than that pointing to the existence of an ovarian cyst or a chronically diseased appendix. Ordinarily the statements of the patient when first seen are not helpful, as is illustrated by the following list of "reasons for seeking the surgeon" in my series: Case I, distention, weight, pain, shortness of breath. Case II, uterine bleeding from multiple myomata. Case III, pain, abdominal distention, vomiting, fever, loss of weight. Case IV, pelvic pain, backache, weakness, loss of flesh, constipation. Case V, pain left side and pelvis, bearing-down feeling, indigestion, loss of weight, menorrhagia. Case VI, fulness of stomach after eating, distended abdomen, frequent micturition, slight pelvic pain. Only in the terminal stages will the patient show weakness, loss of weight and an appearance bordering on cachexia.

The age of the patient is an aid in establishing the diagnosis. While there are a few instances of its occurrence in earlier years, it is generally seen in advanced life, after the menopause and at a time when many lesions of the female genitalia can be excluded. My youngest patient was forty-one years, and the oldest seventy-eight years, the average being over sixty.

Statistics do not seem to help us in determining whether the course is rapid or slow, but a logical deduction from reported cases and those personally observed, would be that it is not rapid until well advanced, and when a part of the original growth has been left at operation. Even at this stage it may be slow, as in case one of this series, which was by far the most severe when first seen, and death did not result for nine years. The other five cases are living at periods of twenty-eight months, twenty-six months, sixteen months, twenty-two months, and twenty-five months after operation. In two of the cases there was recurrence; one after twenty-six months, the other after seven years. Strangely the time of recurrence does not seem to bear any relation to the severity of the lesions.

I feel much more optimistic regarding the outcome of these cases than some previous writers. It will be found stated that recurrence is early, that the incisions are liable to become infected, that pseudomucin is a good culture medium, that the operation is unusually hazardous, and that it should be regarded as a form of cancer. My operative results do not justify these statements. Of the cases here reported the earliest recurrence was in twenty-six months; in no case was the wound infected, although in one case twelve operations were done; intra-abdominal suppuration did not occur; there was no operative mortality, the only death being nine years after the patient was first seen, at which time

there were large tumor masses throughout the abdomen. Weighing against malignancy also is the fact that it is not a rapidly destructive process. Multiple metastases may be widely distributed and the wall of the original cyst, which perhaps has been existent for years, remains intact. The process is not destructive to tissue in the way that is seen in cancer. In only one of my cases was the microscopic appearance even suggestive of malignancy. She was seventy-two years old, is now living, has had no recurrence after more than two years, and reports a gain of between fifty and sixty pounds in weight.

The findings at operation vary in wide degree. In all the reported cases to which I have had access there has been a cyst, either of the appendix or ovary, or both. There is present more or less pseudomucin, which in color is a shade of yellow; in consistency it may be thin, viscid, jelly-like or thick, tenacious and stringy, and it may contain sago-like bodies. If in small quantity it will be free in the pelvis. In larger quantity it may show all the characteristics mentioned, it will be distributed like any effusion, is apt to cling to the peritoneum, and the thicker portion is removed with difficulty. The largest quantity that I have removed at one operation was thirty-five pounds, and the largest total removed from one patient was three hundred and fifty pounds at twelve operations.

In late cases there will be actual tumors on the abdominal viscera and great thickening of tissues. I have seen almost the entire colon enormously enlarged, covered by cysts and nodular formations, and the mesocolon from one-half to one inch thick. These new formations are hard to describe, but when once seen will not be confused with other conditions. They may be made up of small cysts of varying sizes and imbedded in indurated but edematous-appearing structure, and are rather whitish and opaque.

I have noted in my cases that the peritoneum surrounding these secondary growths, as well as that under the jelly-like material in earlier cases, did not simply resemble an inflammation, but bore a stippled or rather fine pebbly appearance without actual macroscopic cystic formation. This I believe to be the early stage of pseudomucinous development in the peritoneum, and when present together with gelatinous material I think we may say we are dealing with pseudomyxoma peritonei. That the lesion need not present a striking appearance to be potent is well illustrated by a case reported by Eden, which he operated twice. At the first operation he mentions the exudate and says, "This jelly-like material was adherent to the peritoneum, which in turn was injected." At a second operation two years later the opposite ovary and the appendix were the sites of advanced lesions. Unless the pseudomucin and cellular elements have been deposited very recently, or are impotent, I think that careful observation will show not only injection

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but the rather diagnostic pebbly appearance of the peritoneum, which is an early stage of cystic development.

It has been pointed out by others, and my observation verifies the view, that all the original tumor should be removed if possible. This is sometimes difficult and even unattainable when adhesions are very firm and highly vascularized. In the only case in which I was compelled to leave a portion of the original cyst wall deep in the pelvis and adherent to the rectum, there was recurrence in slightly over two years. It is unfortunate that the secondary formations cannot always be removed, both to accomplish a cure and for sectioning, the hollow viscera seeming to be most frequently attacked. From one patient I removed a section of the mesentery for examination, without any ill results.

If the original lesion is entirely extirpated, all pseudomucin removed, and affected areas of the peritoneum carefully wiped off with wet gauze, I believe that in early cases cures will often result and certainly the patients may be free from recurrence for many years.

CASE I.—Mrs. B. G., aged sixty-six years, white. Has had paralysis agitans for several years. Nearly three years before coming under observation noticed pain in right lower abdomen and one year ago some swelling in this region. A little later she was conscious of a small tender mass on the left side. Abdominal enlargement had been gradual and there had been some general abdominal pain. There is no history of change in contour of abdomen or disappearance of mass. When first seen the abdomen contained considerable fluid, there was a large irregular mass in the hypochondriac region; another mass was palpable in the suprapubic region. These were firm, movable under the abdominal wall, and in certain areas had rather sharp edges like the liver or spleen.

At operation, July 16, 1907, there was a large thin walled cyst occupying the greater part of the abdominal cavity and attached to the left broad ligament. It contained syrupy, straw-colored fluid. The tumor base, the colon and the entire mesentery were the seats of new growths, the mesentery in places being from one-half to one inch thick. A section of the mesentery was removed for microscopic examination.

She made a perfect recovery and remained free from symptoms nearly seven years, when about thirty-five pounds of gelatinous fluid was removed. From that time on recurrence was more rapid and in the next two years ten operations were done and a total of pseudomucin at the twelve operations was three hundred and fifty pounds. At the time of her death, August twenty-eighth, 1916, the abdomen was well filled with irregular new growth.

*Summarized Pathological Report.*—The section shows a reticulum of fibrous tissues well supplied with blood-vessels and here and there infiltrated with small round cells. Between the fibrous tissue branches are areas made up of fatty areolar tissue, the combination having the appearance of normal omentum. In close connection, between branching arms of fibrous tissue, are areas which

take on a faint blue color and consist of apparently homogeneous semi-fluid material, evidently pseudomucin. The pseudomucinous collections are completely surrounded by the fibrous reticulum, and, for the most part, the enclosed spaces are bereft of any epithelial lining, the pseudomucin being in direct contact with the fibrous tissue. One or two areas are found, however, in which a vestige of epithelium is found lining the pseudomucinous space. This epithelium is of a high columnar type. None of the cells wherever found show any proliferative changes which suggest malignancy. The condition, therefore, is taken to be an implantation metastasis and subsequent growth of particles of a pseudomucinous cyst of the ovary.

*Diagnosis.*—Pseudomyxoma of the omentum and peritoneum.

CASE II.—Miss H. D., aged forty-one years, white. One month previous to admission noticed a small mass in the lower abdomen; for nearly a year has had menorrhagia. She now shows the effects of hemorrhage and hard work. Vaginal examination reveals some small fibromata of the uterus and a left-sided cyst.

At operation, in addition to a fibroid uterus and an ovarian cyst, there was about two ounces of gelatinous material in the pelvis, and the left broad ligament and part of the peritoneum covering the bladder were red and had a pebbly appearance. The appendix was adherent, enlarged and was removed, and a sub-total hysterectomy done.

*Summarized Pathological Report.*—Surface of ovarian cyst is for most part smooth, but there are some adhesions. The lining consists of a single layer of high columnar cells which possess basal nuclei; these are deeply staining. The plasma takes a hematoxylin stain palely. Stroma is made up of loosely arranged connective tissue, which in many areas is edematous. In the smaller loculi the surface epithelium is high, whereas in the larger ones it is comparatively flat. The loculi contain pseudomucin. Nothing suggestive of malignancy is present. The surface of the appendix shows a number of irregular tags and adhesions. In one or two areas the surface is covered by a single layer of flat epithelial-like cells; these are rather small, the nuclei relatively large and deeply staining. The cells are for the most part broader than long; here and there a few which somewhat resemble columnar epithelium are observed. For the most part cells are arranged in a single layer; at two points small elevations are seen which consist of a stroma and are covered by a single layer of the above described cells. Muscularis, mucosa and submucosa show usual changes observed in a mild chronic diffuse appendicitis.

*Diagnosis.*—Cystadenoma ovarii pseudomucinosum glandulare (left); Deposition of pseudomucin upon surface of appendix.

This patient reports herself well three years and four months after operation.

CASE III.—Mrs. M. W., white, aged seventy-eight years, married but nulliparous; never ill in her life except two attacks of influenza; menopause at fifty, without symptoms. Six weeks ago noticed that abdomen was gradually getting larger, and two weeks ago went to bed on account of pain and discomfort, since this time abdominal distension has been rapid. For forty years her abdomen has been "big, but she thought it was her build." There was no change in size of abdomen until six weeks ago. On admission abdomen is

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enormously distended, fluctuation slight, peristalsis good, no edema anywhere, temperature 101, pulse 120, has vomited considerably and has been denied food for several days.

*Operations.*—Small incision under local anæsthesia to evacuate fluid, but it would not run, even with the patient inverted. Palpation through wound discovers small cyst on left covered by nodules. A few days later operated under general anæsthesia; thirty pounds of very thick material, which was for the most part clear, removed; the cyst was deep in the pelvis, covered with cystic nodules, densely adherent to surrounding structures, and the base so firmly attached and so hemorrhagic that a small portion of it could not be removed. Pelvic peritoneum and all pelvic organs show inflammation. Appendix appeared normal.

*Summarized Pathological Report.*—Ovarian cyst shows adhesions, is made up of fibrous tissue with hyaline degeneration present; considerable infiltration of plasma cells, small round cells and few polymorphonuclear leucocytes. Blood-vessels for most part dilated. Inner surface of cyst covered by high columnar type of epithelium, with small oval or round basal nuclei that take hematoxylin stain palely. In no area is there reduplication of the epithelium. Epithelium is very active, many of the cells are swollen, some appear almost bursting with pseudomucin. Much free pseudomucin is also present. Nothing at all suggestive of malignant change is observed.

*Diagnosis.*—Cystadenoma ovarii pseudomucinosum glandulare. Clinically, pseudomyxoma peritonei.

This patient remained free from effusion for two years, and since that time has been tapped twice; her general condition is good. She makes the following written report: "Considering my age, am as strong as I could expect."

CASE IV.—E. G., colored, aged seventy-two years. Patient comes to hospital because of pelvic pain, backache, weakness, loss of flesh, obstipation. She is thin, anæmic, muscles flaccid. Examination shows pelvis to be filled by a firm immobile mass, indicating dense adhesions of organs so that they cannot be defined. Abdomen not distended; no abdominal effusion detected. At operation, November, 1917, pelvis is occupied by a mass in which was fused intestine and overlying this mass about half a pint of gelatinous material. When this is removed and dense adhesions freed there is a small cyst on left side and numerous pockets containing gelatinous material. Cyst is fused to uterus and surrounding structures, is dissected out with difficulty, and uterus is so denuded of peritoneum that it is removed with the cyst and careful peritonization done.

*Summarized Pathological Report.*—Capsule composed of fibrous connective tissue which in some fields presents areas of degeneration and infiltration with inflammatory processes. The inner surface of tumor is covered with a single layer of cells which possess basal nuclei and take hematoxylin stain rather deeply, the cytoplasm takes the eosin stain. The outer cells of the surface are swollen, they contain mucus and in many areas present a bulging appearance. Similar types of cells line all the loculi; in the larger ones the cells are flattened, in the small ones they present the high mucous type of cells previously described.

In some fields numerous small loculi are observed which show little or no intra-glandular stroma and which are highly suspicious of malignancy. The epithelium is more or less regular, and in none is marked kariokinesis present.

*Diagnosis.*—Ovarian cyst reducing pseudomyxoma, which is suggestive, but not positive of malignancy.

This patient is living two years and one month after operation and reports a gain of fifty or sixty pounds in weight and perfect health.

**CASE V.**—E. V. McD., white, aged forty-one years. Patient gives a history of herself discovering a lump in the left lower abdomen last July, which was described as being the size of a goose-egg. Since that time it has grown rapidly in size until it now reaches well above the umbilicus and about three inches to right of median line. It was not accompanied by any pain, discomfort or gynecologic symptoms until about a month ago, since when there has been local left-sided pain, extending somewhat throughout pelvis, a bearing-down feeling, constipation, indigestion, loss of weight and increased menstrual discharge without metrorrhagia. On examination the tumor is to left of uterus, not attached to it and freely mobile, it is evidently a cyst. There is considerable free fluid. At operation, Jan. 28, 1918, about four quarts of thin gelatinous fluid is evacuated. A multilocular cyst attached to left broad ligament and free from adhesions is removed. The parts of peritoneum and intestine in contact with the tumor are red and injected. On exposing the appendix, which is in posterior position, it is small but with thickened wall and almost entirely buried in the coats of cæcum, and has to be dissected out. The cæcum is inflamed, thickened and pebbled in appearance, and covered with thick gelatinous material. Peritoneum over front of uterus and over bladder bears the same appearance. On the peritoneum behind the cæcum are two clear thin-walled cysts as large as an ordinary marble. Right ovary, most of right broad ligament, omentum and mesentery are unaffected. Through error the appendix was not sent to the laboratory.

*Summarized Pathological Report.*—A number of sections all show the same general appearance, that of a pseudomucinous cyst. The one peculiarity is that the epithelium appears unusually active; the cells are, if anything, rather higher type than usual, and many are absolutely loaded with pseudomucin. No suspicion of malignancy is observed. There is, however, in some areas a well-defined inflammatory reaction consisting of plasma cells, polymorphonuclear leucocytes, and here and there infiltration of free blood is observed.

*Diagnosis.*—Cystadenoma ovarii pseudomucinosum glandulare (myxoma peritoneal from history).

In her own recent report of her condition she states that she is well and her weight has gone from one hundred pounds to one hundred and sixty pounds at present.

**CASE VI.**—L. S., white, aged sixty-two years. About ten years ago noticed slight general enlargement of abdomen, which has increased very slowly, and for last three years has had some pain on moving about and when lifting; frequent micturition, indigestion

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and constipation. On admission the abdomen is distended, there is a tumor and free fluid.

At operation a right ovarian cyst weighing twenty-five pounds is removed. There is evacuated from the abdominal cavity six pounds of free, amber, gelatinous fluid. The appendix is converted into a multilocular cyst, larger at the base than at the tip, the average diameter being about three-quarters of an inch, and containing clear gelatinous fluid. The cæcum was much thickened and injected. Balance of intestine and the peritoneum appear normal. Cyst is multilocular and the content similar to that free in the abdominal cavity. In this case only the appendix was sent for examination.

*Summarized Pathological Report.*—Peritoneal surface of appendix shows adhesions. In some sections the musculature is thickened, but in others very thin and drawn out. All layers are more or less thin in some sections. The chief histologic change, however, is found in the epithelium. This is unusually luxuriant, swollen, filled with mucus and presents basal nuclei; takes hematoxylin stain palely; nothing suggestive of malignancy. Sections from small cyst show this to be lined by a similar type of cell as that just described. Here the gland-like arrangement is somewhat irregular and there is a definite formation of the glands. In no area, however, is there penetration of the basement membrane, and the only thing at all suggestive of malignancy is the marked increase in the number and size of the glands.

*Diagnosis.*—Pseudomyxoma peritonei; Mucocoele of appendix; Ovarian cyst; Retention cyst of appendix.

This patient has had no return of symptoms and is reported as thoroughly well.

### CONCLUSIONS

1. This condition is much more frequent than is generally recognized.
2. It is caused by cellular implantation.
3. It is histologically benign, but may be clinically malignant.
4. If it is considered to be a form of cancer, it must be assumed that pseudomucin inhibits its destructive power.
5. It may originate in the ovary or the intestinal tract; ovarian origin being by far the most frequent.
6. If it is appendiceal in origin, the appendix has been the seat of chronic inflammation.
7. Early invasion of the peritoneum is characterized by a pebbly appearance.
8. In early cases the condition will sometimes be cured, and at any stage it may be inhibited, by operation.

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## SARCOMA OF THE STOMACH \*

WITH REPORT OF THREE CASES

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ALTHOUGH carcinoma is of common incidence, primary sarcoma of the stomach is one of the most unusual forms of neoplasm occurring in that viscus. Its literature is, therefore, largely made up of isolated case reports with but few special articles, and little or nothing is found in most text-books on this subject. Having had the opportunity of operating on three cases, my interest was stimulated to a search of the literature, and to make an attempt to gather therefrom some knowledge of the surgery of this disease. This, with the three case reports, is the basis of this paper.

*Frequency of Occurrence.*—Fenwick, in 1902, stated that sarcoma occurred in 5 to 8 per cent. of stomach tumors. Yates, in 1906, 2 per cent., based on records of 800 cases of tumor of the stomach. Ewing, in 1919, gives 1 per cent. Smithies and Ochsner, in 1919, in an analysis of 921 cases of cancer of the stomach, found but 4 cases of sarcoma. Ziesche and Davidsohn, in 1909, from the statistics of various German operative clinics and autopsies estimate 1 per cent. Two of the cases here reported are the only cases of sarcoma of the stomach to be found in the operative records of Bellevue Hospital. During the period from January 1, 1911, to July 1, 1919, eight and one-half years, there were 702 cases diagnosed as carcinoma of the stomach on discharge from Bellevue Hospital. As there were only 97 operations for carcinoma of the stomach and the percentage of autopsies was small, there is the possibility that several of these cases were incorrectly diagnosed. It is of interest to note that of the 97 operative cases of carcinoma, 48, or nearly 50 per cent., died while still in the hospital. The other case of sarcoma of the stomach here reported is the only one from the surgical records of St. Luke's Hospital, N. Y.

*Age.*—The average age of incidence of carcinoma of the stomach, according to the United States Census report of 1911, was 61.2 years. Sarcoma, however, as a rule, occurs in younger patients. Ewing states that lymphosarcoma occurs chiefly in young subjects. The age of the patients with sarcoma reported in the literature ranged from three and one-half to ninety-one years. In a series of 150 cases reported by Ziesche and Davidsohn in 1909, in 118 of which the age was given, the age by decades was first decade, 3; second, 11; third, 18; fourth, 15; fifth, 29; sixth, 24; seventh, 12; and eighth, 6. The average age being 41.6. In a smaller series reported by Burgaud in 1908 the results by decades were practically the same.

Forni estimates the period of greatest frequency of occurrences of sarcoma of the stomach as forty to sixty. The average age for lymphosar-

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coma is given as thirty-six years. In the cases of my own three patients the ages were thirty-six, thirty-eight, and forty-one years.

*Sex.*—The sex of the patients has been almost equally divided in the reported cases.

*Etiology.*—Ewing states: "The occurrence of atypical productive inflammatory lesions must be regarded as fully in accord with established views regarding the nature of sarcoma; that is, the inflammatory origin of sarcoma, especially lymphosarcoma." He quotes Moser and Kehr that "sarcoma may follow ulcer appears possible, but this relationship has not been satisfactorily proven." This relationship is denied by Lecène and Burgaud, and Levine writes: "Lymphosarcoma is only a manifestation of a systemic disease which embraces the whole lymphoid system. A discrete tumor of lymphosarcoma is always surrounded by diseased lymphoid tissue, and the operation is followed not by a recurrence, but by the development of the latter tissue into new tumors." This latter statement would appear to be effectually disproven by the number of cases which have survived operation for a considerable time—one case reported as being without recurrence fourteen years after operation. In the specimen shown in the illustration it appeared by gross examination as if the large sarcomatous ulcer had originated from the edge of an older cicatrizing ulcer near the pylorus, but this was impossible to prove by microscopical examination.

*Pathology.*—Sarcoma of the stomach may be divided into three distinct groups of cases: (1) Spindle-cell myosarcoma; (2) lymphosarcoma; (3) miscellaneous round-cell or lymphosarcoma, the nature of which is uncertain. They may be diffuse, involving the whole stomach, or form large masses or be polypoid. Cantwell removed one weighing 12 pounds. Barrington Ward reports a case in which the mass projected into the stomach cavity near the pylorus in such a manner as to obstruct the exit of the stomach. A considerable number of cases are reported as exogastric tumors. They have, therefore, been classified by Burgaud as exogastric, endogastric, and infiltrating.

As the round-cell variety and lymphosarcoma originate in the submucous layer and the spindle cell in the muscular layer, ulceration does not occur as readily as in carcinoma, which originates in the epithelial layer. Lymphosarcoma and the round-cell variety are usually infiltrating, while the spindle cell or myosarcomata form discrete tumors which may either be sessile or peduncleated and often grow to a large size. At a recent meeting of the New York Pathological Society Pagenstecher showed a specimen of myosarcoma which weighed 11 pounds. Cystic degeneration of these larger tumors not infrequently occurs.

Concerning the relative frequency with which the various forms of sarcoma occurred, Fornì, in an analysis of 200 cases, in 190 of which the variety of the lesion was noted, found round-cell (including lymphosarcoma) in 98, spindle-cell in 39, polymorphous structure in 14, and special forms as

angio or myosarcoma in 39. According to Hesse, perforation occurs in 8 per cent. of the cases.

Round-cell and lymphosarcomata increase more slowly in size than spindle-cell, and, judging from the statistics of the progress of the disease, cases of sarcoma of the stomach metastasize less rapidly than carcinoma, and the length of life after the appearance of the disease in non-operative cases appears to be longer than in carcinoma cases. Therefore, operative results should afford a better prognosis than in carcinoma ventriculi.

It would appear that a benign tumor, as a leiomyoma, may exist for years, grow slowly, and then become sarcomatous. Kimpton reports such a case in a woman of thirty, in whom he resected the stomach for a round-cell sarcoma. The patient stated that she first noticed the tumor when she was eleven years old.

*Metastases.*—While forming less rapidly than in carcinoma, metastases, when they do occur, are most frequently found in the lymph-nodes in relation to the stomach, and secondly in the liver, as occurs in carcinoma. In only one of my three cases, Case I, were the glands involved, in which instance they were of considerable size, and of a consistency and appearance that made the operative diagnosis of sarcoma probable.

*Location of the Lesion.*—An analysis of 146 cases in which the location of the lesion was given, published by Flebbe in 1913, showed it to be located at the pylorus in 37; greater curvature, 30; posterior wall, 26; lesser curvature, 13; anterior wall, 8; cardia, 3; pylorus and both curvatures, 2; while in 27 cases almost the entire stomach was infiltrated.

*Symptomatology.*—As a rule, a previous history of gastric disturbance is absent in sarcoma of the stomach. Pain is the most constant symptom and is present in most cases; but the amount of pain as with the other symptoms would appear to depend somewhat on ulceration. Vomiting, and especially hæmatemesis, is less frequent than in carcinoma, and as the growth does not so often affect the pylorus, or even if in the pyloric region, is not as apt to cause stenosis as is carcinoma, the symptoms of pyloric obstruction are not so common. Cachexia develops more slowly than in carcinoma, but anæmia is mentioned as a frequent symptom. In none of my three cases was the latter of prominence. The presence of an inflammatory leucocytosis has also been recorded. Albumen in the urine is mentioned as one of the occasional symptoms. This is explained by the presence of metastases in the kidney and therefore would not be a symptom of a stomach sarcoma, and if not due to coincident nephritis, would contraindicate operation. When the growth is infiltrating a mass may not be felt, but in some of the infiltrating cases and many others a palpable tumor is present, especially in the case of exogastric tumors, which grow to a large size. In one of my cases, although the tumor was of the infiltrating lymphosarcoma type, the mass formed by the enlarged glands could be palpated before operation. Schlesinger states that an enlargement of the spleen is found in 10 per cent. of the cases of sarcoma

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of the stomach, especially in lymphosarcoma, although this is not necessarily due to metastasis.

The examination of the gastric contents in carcinoma usually shows the absence of free hydrochloric acid. This, while not absolutely diagnostic, is of aid in making the diagnosis. In sarcoma free hydrochloric acid is apt to be present, although frequently absent. In both of my cases in which a gastric analysis was done free hydrochloric acid was present in the expressed test meals. Blood in the stomach contents or stools is not as frequently found as in carcinoma. Occasionally cellular elements from the tumor may be found in the return from a test meal or gastric lavage which would indicate the presence of sarcoma.

*Radiographic Examination.*—Although a positive diagnosis of sarcoma could not possibly be made by a radiographic examination, the X-ray is the greatest aid we have in making a diagnosis of the presence of an operative lesion. Deformity of the stomach, filling defects, irregularity of the outline, interference with the peristaltic waves, the relation of the stomach to an exogastric tumor, all point to a necessarily operative condition, which, after all, is the closest we can hope to come in the pre-operative diagnosis of most gastric disorders.

It has been suggested that an infiltrating tumor may be diagnosed by a fluoroscopic examination demonstrating the inability of pressure with the hand to indent the infiltrated stomach wall. Also where so large a portion of the stomach is shown to be infiltrated that operative cure is impossible, the careful radiographic examination can prevent unnecessary surgery in a hopelessly inoperable case. In two of my cases which were radiographed, a radiographic diagnosis of ulcer was made in one and of carcinoma in the other.

*Cases Reported in the Literature.*—In the 150 cases reported by Ziesche and Davidsohn in 1909, the majority were from autopsy reports; there were 52 operative cases. Of these 31 were exogastric tumors. In 25 of these resection of the tumor was reported, 7 died as a result of operation, 11 recovered, but no subsequent report was made, while 7 were reported well three months to three years after operation. In the other 6 exogastric tumors, where operative procedure other than resection was resorted to, all died. Of 21 gastric tumors, 12 were resected and 5 died. Of 5 that recovered there were no subsequent reports and two were reported well, one case a year, and the other four years after operation.

In 9 gastric tumors in which resection was not performed, 4 being gastroenterostomies and 5 exploratory laparotomies, all died. Thus there were 37 resections of which 25 recovered, a mortality of 32 per cent.

Frazier, in 1913, reported 28 operative cases. Of these 11 correspond to Ziesche and Davidsohn's list of operations, one of them being an exploratory laparotomy. There are 17 additional cases in Frazier's list, 7 of which were reported subsequent to Ziesche and Davidsohn's paper. He does not include, however, 16 exogastric resections, 11 resections of gastric tumor,

and 14 cases, operated on by other methods than resection, in the list of Ziesche and Davidsohn. This makes a total of 69 operations and 54 resections up to 1913. It is of interest to report here that one of these patients in Frazier's list operated on by Moschowitz in 1909 died in 1919 of another disease with no signs of recurrence of the sarcoma. Kimpton has recently reported a case without recurrence five years and ten months after operation for round-cell sarcoma; and the case reported by Rupert operated on by Schopf was well fourteen years after operation. The most complete analysis of the largest number of cases that I have been able to find in the literature is that of Forni, published in 1914, who brought the list of reported cases up to 200. A complete bibliography is included in his report.

Since the report of this group of cases the following cases have been reported, or were not included therein:

HUNTINGTON: Woman, aged 67 years, fibrosarcoma, size of cherry, originating in pyloric region. Resection of pylorus. Reported well two months later.

MAYO, W. J.: Man, aged 38 years, resection of stomach for tumor size of head lying in pelvis. Recovery. Death in six months from recurrence.

MAYO, C. H.: Man, aged 43 years, intrinsic myxosarcoma. Patient well at end of one year.

MEDINA AND EGANA: Man, aged 37 years, fibrosarcoma of lesser curvature and posterior wall with pylorus intact. Resection, with anterior gastro-enterostomy. Patient well one and a half years later.

BARRINGTON, WARD: Man, aged 25 years, round-cell sarcoma, size of fist, growing from pyloric region in stomach. Successfully resected.

FRITZESCHE: Reports a case of sarcomatous leiomyoma of the stomach operated on by Quervain, which had perforated, the tumor originating from the greater curvature.

HARTZ: Man, aged 41 years, round-cell sarcoma of the anterior wall and lesser curvature of the stomach. Exploratory laparotomy by Montgomery. Died sixteen days later.

KIMPTON: Woman, aged 30 years. Multiple pedunculated round-cell sarcoma, involving pyloric end of stomach. Well five years ten months after resection.

SCHLESINGER: Boy, aged 17 years, operated by Föderl. Lymphosarcoma of pylorus. Resection; recovery. Man, aged 32 years, lymphosarcoma of cardia and posterior wall. Extensive metastasis. Exploratory laparotomy. Man, aged 66 years, diffuse lymphosarcoma, involving middle of stomach between cardia and pylorus. Extensive metastasis. Exploratory laparotomy.

Seven cases are reported from autopsy records. Two by Warner, both of which were leiomyosarcoma, one from the greater curvature and the other from the pyloric region. One of fibromyxosarcoma, by Rohdenburg, and one of myosarcoma which weighed eleven pounds, by Pagenstecher. Two by Giacomini, one of which, a man aged 65 years, had a round-cell infiltrating submucous tumor forming several polypoid masses, the other a woman, aged 91 years, with a round-cell sarcoma infiltrating the pylorus. Saito reports the autopsy on a woman, aged 27 years, with an infiltrating tumor of the lesser curvature from the pylorus to the cardia, which showed mixed tissue elements of myxosarcoma and carcinoma cells, or a true carcinosarcoma.

In addition to these 18 cases, 7 cases from the literature not included in the list of Forni collected by Medina and Egana, and the 3 cases of resection reported by the writer, making a total of 228, there are articles and case reports noted in the Index Medicus for 1914 to 1919 by Burty,

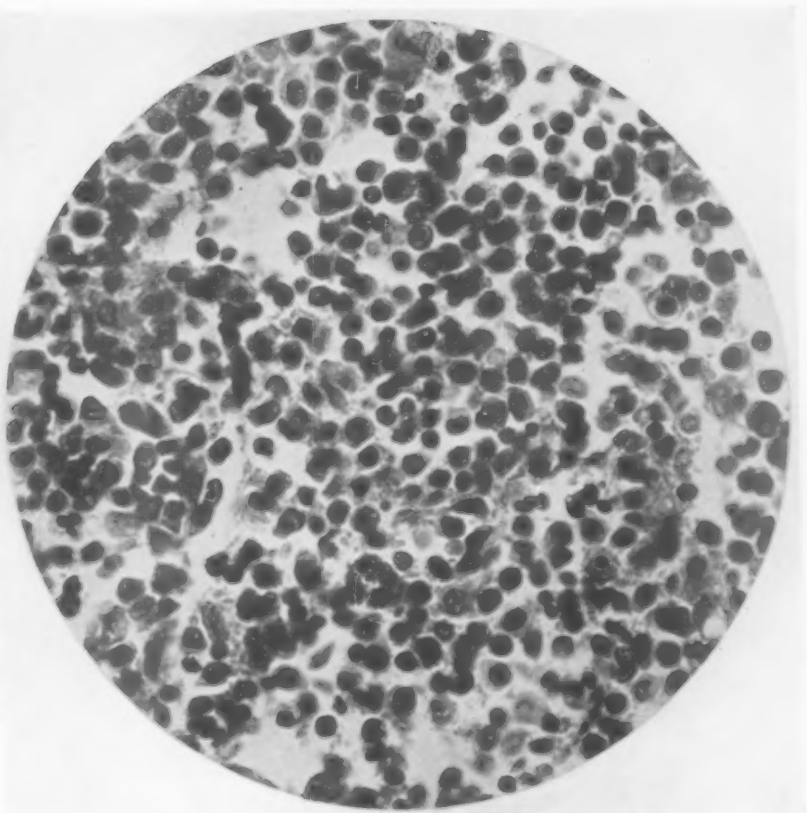


FIG. 1.—Case I. Sarcoma of stomach. Section through tumor.  $\times 600$ .

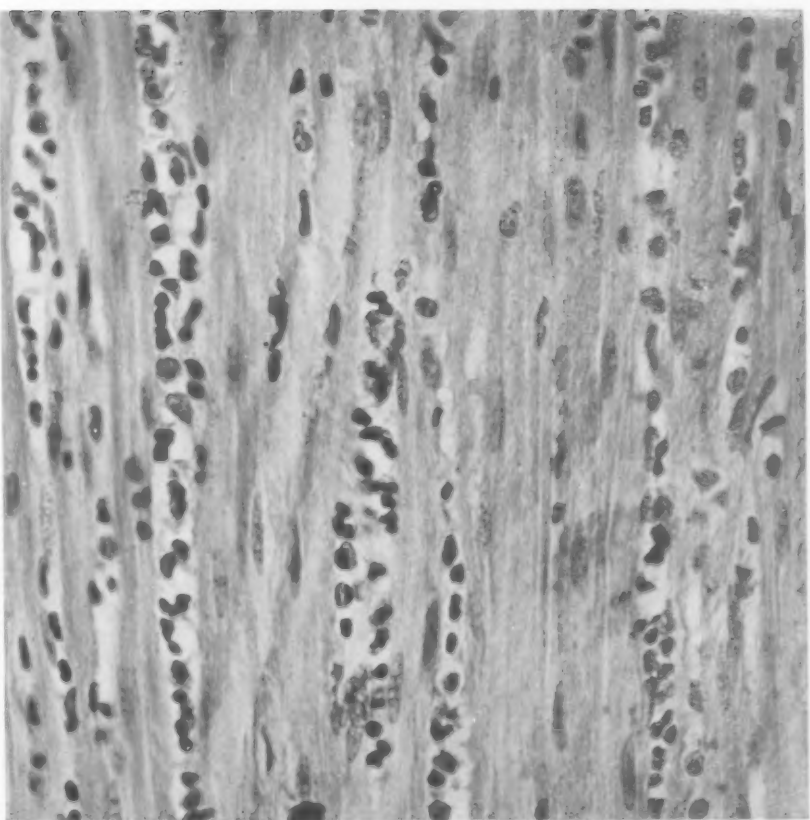


FIG. 2.—Case I. Sarcoma of stomach, showing infiltration of stomach walls with tumor cells.  $\times 600$ .



FIG. 3.—Case III. Section of stomach removed, showing sarcomatous ulcer.

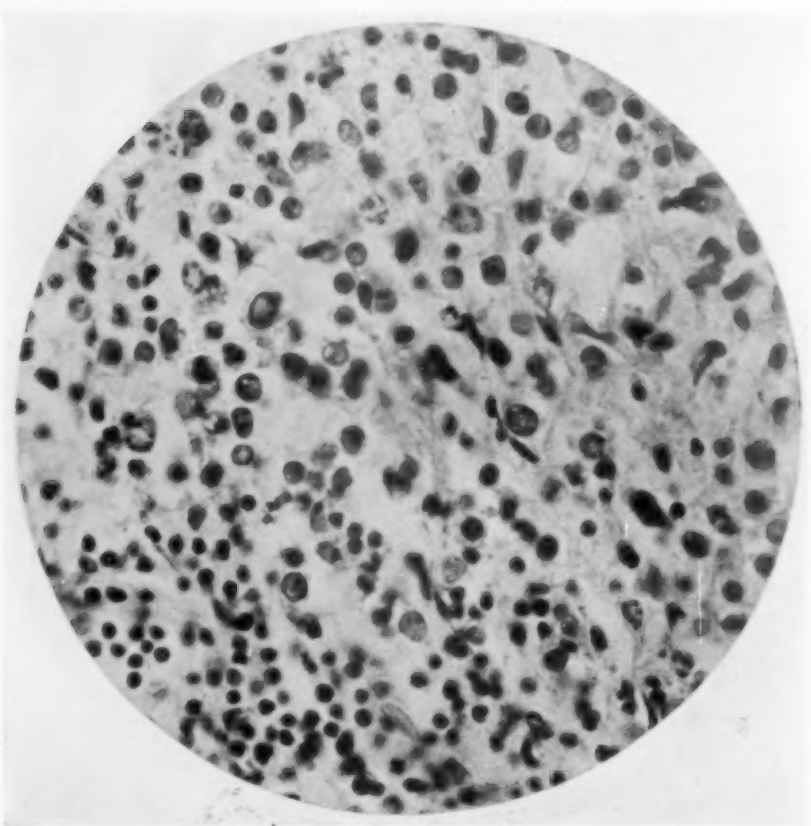


FIG. 4.—Case III. Sarcoma of stomach. Section through tumor.  $\times 600$ .

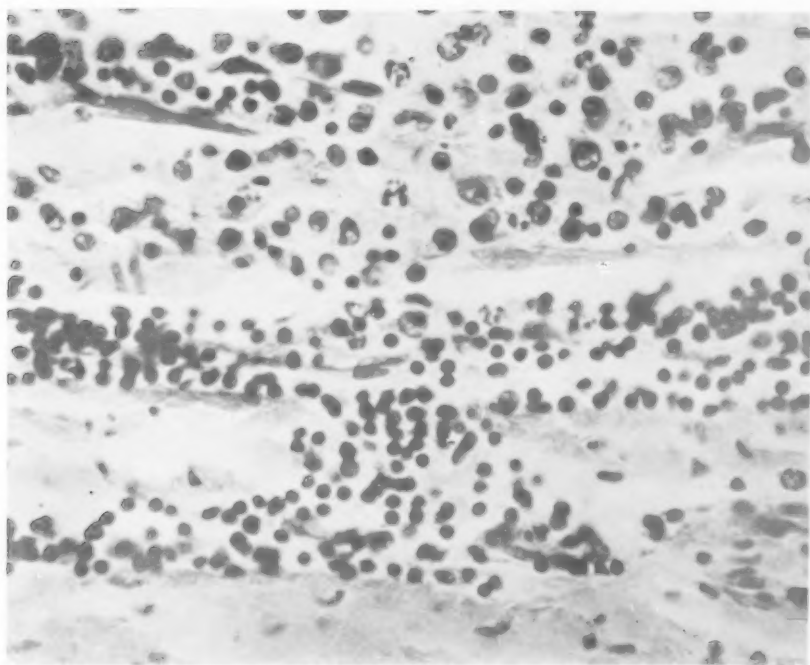


FIG. 5.—Case III. Sarcoma of stomach, showing infiltration of stomach wall with tumor cells.  $\times 600$ .



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Geymuller, Hesse, and Koettlitz, but none of the journals containing these articles are at present obtainable at the New York Academy of Medicine. The articles by Burty and Koettlitz are each reports of one case, making 230 cases reported in all.

The following is a brief report of the three cases reported on by the writer of this paper:

CASE I.—Woman, aged thirty-eight years, admitted to St. Luke's Hospital May 27, 1917. Had an appendectomy four years ago for symptoms of indigestion which were not relieved by the operation. Symptoms have been worse for past six months when she developed pain in the right hypochondrium made worse by eating.

Examination revealed an irregular mass in the right hypochondrium. No radiograph examination or gastric analysis was done as a preoperative diagnosis of cholecystitis was made. At operation the pyloric end of the stomach was found greatly infiltrated, the wall measuring 1.5 cm. in thickness. There were a number of enlarged white lymph-nodes along the greater curvature, the largest of which was 2.5 by 2 cm. in diameter. The pyloric third of the stomach was resected, an operative diagnosis of sarcoma being made. Operation was difficult on account of the large blood-vessels about the stomach and glands. The patient died of hemorrhage and shock the following day. "Examination of the specimen showed lymphosarcoma in the stomach and glands" (Figs. 1 and 2) (Dr. F. C. Wood). Mucous membrane not ulcerated.

CASE II.—Woman, aged forty-one years, admitted to Bellevue Hospital on July 24, 1917. Had been operated on one year previously for a gynæcological condition. Had belched gas after meals for two years. Had lost 40 pounds in weight in last year. Pain in epigastric region and occasional vomiting for past few weeks. Gastric analysis after Ewald meal showed total acidity of 38. No free hydrochloric acid, lactic acid, blood or bile. After a Boas meal free hydrochloric acid was present. Urine examination, blood examination, and Wassermann negative. X-ray examination indicated the presence of ulcer of the pylorus. No mass could be felt.

At operation an infiltration of the pyloric end of the stomach was found. It was not adherent and the glands were not enlarged. A resection of the pyloric third of the stomach was done by the Billroth No. 2 method. The patient made a good recovery from the operation. She was allowed up in a chair sixteen days after operation with the wound healed, but she did not regain strength and vomited at times. Her mind was cloudy and the patient died twenty-three days after operation.

*Pathological Diagnosis.*—Lymphosarcoma of stomach (Dr. Chas. Norris).

CASE III.—Man, aged thirty-six years, admitted to Bellevue Hospital September 22, 1918.

Had been operated on in another hospital one year previously for varicose veins of the legs. No history of gastric disorder pre-

vicious to three months before admission, when he began to have pain and distress in his epigastrium and right hypochondrium, at first in no relation to meals, later after eating. Did not vomit until two nights before admission. Had lost 15 pounds in weight.

*Gastric Analysis.*—Total acidity, 22; free hydrochloric acid, 16; lactic acid, 0; urine, negative. Blood examination: Red blood-cells, 4,422,000; hæmoglobin, 78 per cent.; white blood-cells, 11,000; polynuclear cells, 77 per cent.

X-ray examination revealed a marked deformity of the stomach, a diagnosis of perforating carcinomatous ulcer being made.

At operation a large callous ulcer of the posterior wall was found which had perforated and was adherent to the pancreas (Fig. 3). There were no enlarged glands. The stomach was separated from the pancreas with difficulty and resection of one-third of the stomach by the Billroth No. 2 method was done. Examination of the specimen showed lymphosarcoma (Figs. 4 and 5) (Dr. Douglas Symmers). The detailed report by whom is here given:

"Microscopic examination of the stomach shows the presence of extensive necrosis of the mucous membrane. The muscular wall is enormously infiltrated and destroyed by cells, some of which are the type of small lymphocytes, but most of which are apparently large lymphocytes.

"Assuming that the blood was examined during life and that no evidences of lymphatic leukæmia were detected, the best interpretation of the histological findings would appear to be that of a growth belonging in the category of the lymphosarcomata.

"In this connection it is interesting to recall that the stomach is occasionally the seat of a growth of similar histological appearances which, after the lapse of a certain length of time, suddenly commences to pour its cells into the blood stream, constituting a true leucæmia. The latter phenomenon is rapidly followed by death. This is the so-called leucosarcoma of Sternberg. It is possible that this case is an example of this lesion. It is likewise interesting to note that there are varieties of lymphosarcoma which, after attaining relatively enormous proportions, undergo involution and disappear either spontaneously or under the influence of such applications as radium or the X-ray. Thus the lymphosarcomata vary greatly in malignancy."

The patient made an excellent recovery and has no symptoms of recurrence sixteen months after operation.

#### SUMMARY

Sarcoma of the stomach occurs in 1 per cent. of all stomach tumors. The average age of incidence is 41.6, in contrast with an average age of 61.2 for carcinoma. The average age for lymphosarcoma is earlier than in the other forms.

Round-cell and lymphosarcoma are the most frequent forms found. They are more apt to be infiltrating, but the round-cell may project into

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the stomach or form peduncleated tumors. They result in ulceration oftener than in other sarcomata, but not as frequently as in carcinoma. Spindle-cell and myosarcoma are apt to form large exogastric tumors. While statistics show that the most common site is in the region of the pylorus, especially in the infiltrating form, other portions of the stomach are more frequently involved, and the pylorus itself is less often attacked or obstructed than in carcinoma. Metastasis also occurs less rapidly than in the latter, and the operative prognosis should therefore be better.

The diagnosis can rarely be made with certainty; the X-ray examination furnishes the most useful evidence. When in the presence of a tumor in a patient younger than those in which cancer is usual a short history of gastric disturbance, absence of blood in the gastric contents and stool, and the presence of free hydrochloric acid, the absence of cachexia, and the presence of anæmia, while not ruling out cancer, ulcer, or syphilis of the stomach, may cause the diagnosis of sarcoma to be considered.

The total number of authenticated cases now recorded is brought up to 230 with a probable larger number on record, the reports of which are not now available. To the number of operative cases, in addition to the 69 previously reported in the lists of Ziesche and Davidsohn and of Frazier, may be added the 8 cases from the literature collected by Medina and Egana, one case in this list being reported by Forni, but not included in the operative list, one case by Forni, the additional 11 reported in this paper, and the 3 cases of the writer, a total of 92 operative cases, of which 69 were resections either of the exogastric tumor or of part of the stomach and 23 were either gastroenterostomies or exploratory laparotomies.

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## HYPERPLASTIC TUBERCULOSIS OF THE INTESTINES \*

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THE abdominal surgeon encounters tuberculosis in various forms with moderate frequency.

The serous form of tuberculous peritonitis is not uncommon and is often surprisingly benefited by laparotomy with the removal of the vermiform appendix or Fallopian tube, which may be found to be the focus of infection.

In plastic or sero-fibrinous tuberculous peritonitis, however, and in ulcerative entero-peritoneal tuberculosis, where interference may be necessary for the relief of intestinal obstruction or fecal abscess, the prognosis is much less favorable; for the disease is likely to continue its progress and the obstruction to recur, despite an operation, which may have consisted in mere separation of adhesions, or a side-tracking anastomosis or a resection.

Tuberculosis, limited to the Fallopian tubes or to the appendix, is occasionally found at operation upon those organs and their early excision may prevent the development of a generalized tuberculous peritonitis. In these cases the diagnosis is frequently made by the pathologist.

The form of tuberculosis with which we are to deal in this paper is the chronic hyperplastic tuberculosis of the intestines, which, although comparatively rare, affords an interesting field for radical surgery.

From its seat of election it has been variously designated as "ileo-cæcal tumor" (Duranti); "typhilitis resembling cancer" (Hartmann); "the real surgical tuberculosis of the cæcum" (Berard).

Factors which constitute indications for surgery in this condition and which at the same time definitely influence the results obtained are the slow growth of a painless tumor; with a strong tendency to stenosis and to chronic obstruction: the limited area of involvement, permitting of excision; the attenuation of the tuberculous infection in the lesion and the comparative freedom from association with active pulmonary tuberculosis.

Of the six cases of chronic hyperplastic tuberculosis of the intestines recorded below, five occurred in the service of the Second Surgical Division of the New York Hospital, and are published by the courtesy of Dr. Eugene H. Pool, chief of service, and of Dr. F. W. Bancroft, whose operative cases are included in this report.

The sixth case was operated upon by the writer at Bellevue Hospital in 1913, and the patient was shown before the Surgical Section of the New York Academy of Medicine, March 4, 1914.

CASE I.—*Chronic hyperplastic tuberculosis of the cæcum. Operation. Resection of the cæcum. Side-to-side ileo-colostomy. Recovery.*  
Mohammed B. Hindu from East Indies, aged 20 years. Tailor.

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\* Read before the New York Surgical Society, February 6, 1920.

Admitted to the New York Hospital, April 22, 1918. Discharged May 14, 1918.

Chief complaint: Cramp-like pains in right lower abdomen.

Past history: Denies any previous illness.

Venereal history is negative.

Present illness: This began 2½ months ago with cramp-like pains centering about the umbilicus and later localized in the right lower quadrant. There was no vomiting, constipation nor diarrhoea.

After a few days the pains passed away and the patient has felt well until four days ago.

Four days ago there occurred a similar attack of severe cramping pain, at first general, and later localized in the right lower quadrant, with constipation, but without vomiting. No urinary symptoms.

Physical examination on admission showed an undernourished young Hindu who did not appear acutely ill. Temperature, 100° F.; pulse, 88; respiration, 22.

Lungs showed signs of old inactive tuberculosis at both apices.

Abdomen was thin walled and not rigid. In the right lower quadrant was palpable a firm, oval, slightly tender mass in the region of the cæcum and slightly movable laterally.

Admission diagnosis: Subacute appendicitis.

Operation by Dr. Seward Erdman, April 23, 1918: Right rectus incision. No free fluid was encountered, nor was there the appearance of any acute inflammatory process. The appendix and the cæcum proper were moderately thickened, but the ascending colon from the level of the ileo-cæcal valve nearly up to the hepatic flexure was very markedly thickened, tumefied and with a dull red, roughened serosa presenting tiny elevations which resembled tubercles.

The external diameter of the colon was slightly larger than normal, but the great thickening of the walls caused an almost complete occlusion of the lumen.

The mesenteric lymph-nodes adjacent were enlarged to the size of from 1 cm. to 2.5 cm. in diameter.

Elsewhere in the abdomen the intestines and the peritoneum appeared and felt normal.

The cæcum was then resected, including three inches of ileum and the ascending colon up to the hepatic flexure, and a side-to-side ileo-colostomy performed, using the transverse colon.

*Pathological Report.*—Tuberculosis of cæcum. Mucosa of cæcum at orifice of appendix presents an ulcer area 4 cm. in diameter. The walls of the cæcum are very much thickened and contain tubercles.

*Post-operative Notes.*—Convalescence was very smooth. There was slight superficial wound drainage and the patient went home on the twentieth day after operation. Weight on discharge was 95 pounds.

*Follow-up Notes.*—At eighteen months after operation, the patient is working as usual and in better physical condition than when he was in the hospital. He has no complaints and the bowels are regular, daily.

At twenty-two months after operation, he remains perfectly well and has gained over 15 pounds in weight.

CASE II.—Chronic hyperplastic tuberculosis of ileum and cæcum.

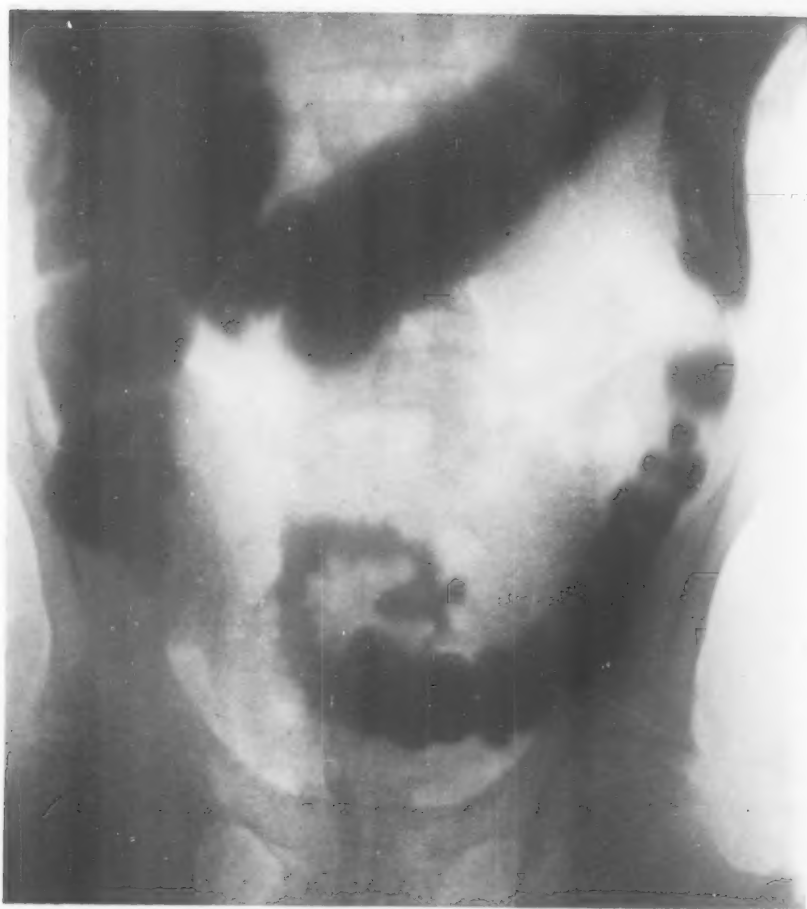


FIG. 1.—Case II. Hyperplastic tuberculosis of ileum, cæcum, and rectum. Barium enema shows filling defect of rectum, suggesting neoplasm.



FIG. 2.—Case III. Hyperplastic tuberculosis of sigmoid after barium enema, showing filling defect in sigmoid suggestive of neoplasm.

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*Stricture of rectum. Operation. Resection of cæcum and 16 inches of terminal ileum. Ileo-sigmoidostomy. Left inguinal colostomy. Died in hospital.*

Benjamin W., Austrian, aged thirty-two years. Admitted to the New York Hospital, November 5, 1917. Died November 3, 1917.

Chief complaint: Cramp-like abdominal pain. Bloody diarrhoea.

Past history: In 1910 was operated upon for hemorrhoids at another hospital, but an ulcerated condition was found.

In 1911, at another hospital, a temporary right inguinal colostomy was performed, to permit irrigations of the colon with silver nitrate solutions.

Venereal infection is denied and the Wassermann is negative.

Present illness: About seven months ago he began to suffer from severe cramping abdominal pain, coming on immediately after food and lasting about an hour. Also there occurred profuse diarrhoea, 15 to 20 stools a day, with mucus and occasionally blood. Loss of weight is estimated at 20 pounds in the past seven months.

Physical examination on admission: Temperature, 100°; pulse, 100.

Lungs reveal signs of an old tuberculous process at the left apex.

Abdomen: There is a small incisional hernia at the site of the healed colostomy wound in the right lower quadrant.

Rectal examination shows hemorrhoids and higher up a partial stricture of the rectum.

Stool examinations in the hospital did not show any blood.

X-ray examination after a barium enema revealed a filling defect of the lower sigmoid and rectum, suspicious of a neoplasm (Heren-deen) (Fig. 1).

Operation by Dr. F. W. Bancroft, November 14, 1917.

Right papamedian incision in lower abdomen.

The terminal ileum and the cæcum were found very markedly thickened and the lumen much diminished.

The cæcum and about 16 inches of terminal ileum were resected and an ileo-sigmoidostomy was performed, to which was added the first stage of a left inguinal colostomy below the anastomosis, for the purpose of better drainage on account of the rectal stricture.

This sigmoid loop was opened with the cautery forty-eight hours after operation.

*Pathological Report.*—Chronic tuberculosis of the intestine.

*Post-operative Notes.*—There was considerable shock. Drainage was profuse. There were signs of peritoneal irritation, hiccough and vomiting, and the patient died on the ninth day after the operation. No autopsy.

*CASE III.*—Chronic hyperplastic tuberculosis of sigmoid. Chronic ulcer of rectum and hemorrhoids. Operation. Exploratory laparotomy. Hemorrhoidectomy. Improved.

Peter McE., U. S., aged twenty-nine years. Admitted to the New York Hospital, May 18, 1917. Discharged, improved, June 2, 1917.

Chief complaint: Pain in lower abdomen. Diarrhoea.

Past history: No previous illnesses.

Venereal disease denied and blood Wassermann negative.

Present illness dates from four months ago, when he began to suffer from constipation, hemorrhoids and bloody stools, associated with occasional dull pains in the left lower quadrant of the abdomen.

Five days ago, after lifting a heavy weight, he felt "dizzy and heavy" and had diarrhoea with nausea, but no vomiting. There was dull pain in the lower abdomen and general weakness.

Physical examination on admission: Temperature, 100.8° F.; pulse, 86. Lungs, negative.

In the abdomen there was palpable a sausage-shaped mass about 10 x 5 cm. in diameter in the left lower quadrant, which was slightly movable. There was no great tenderness and no rigidity.

Rectal examination showed a moderate hemorrhoidal condition and a small ulcer about 1 cm. in diameter, just above the sphincter ani.

X-ray examination after a barium enema showed a filling defect which was regarded as suspicious of a new growth of the sigmoid (Busby) (Fig. 2).

Operation by Dr. Seward Erdman, May 23, 1917: Exploratory laparotomy.

The general abdominal cavity was free from pathology, but a segment of the lower sigmoid about 10 cm. in length was found deeply congested in appearance and with pronounced thickening of its walls.

This thickening was symmetrical and involved the entire circumference of the bowel. The serosa over it had the sand-paper appearance suggestive of tuberculosis.

The lumen was only slightly encroached upon. There was no sign of ulceration, neoplasm or diverticulitis.

The mesenteric lymph-nodes adjacent were enlarged and one was removed for examination.

The abdomen was then closed.

The hemorrhoids were then excised, together with the soft ulcer of the rectum.

*Pathological Report.*—Sections of the ulcer of the rectum showed only chronic inflammation. The mesenteric lymph-node was, unfortunately, lost and not examined.

*Post-operative Notes.*—The wound healed per primam and the patient went home on the tenth day after operation.

*Follow-up Notes.*—Eighteen months after operation patient is very well and working and has gained 20 pounds in weight. He is constipated and has occasional pains in abdomen.

*CASE IV.—Chronic hyperplastic tuberculosis of the cæcum. Operation. Resection of cæcum and 20 cm. of terminal ileum. End-to-side ileo-colostomy. Recovery.*

Rosie M., Italian woman, aged forty-two years. Admitted to the New York Hospital October 20, 1919. Discharged improved, November 21, 1919.

Chief complaint: Pain in right lower abdomen with vomiting.

Past history, as obtained through interpreter, was negative as to past illnesses. Has had four normal confinements.

Venereal history and blood Wassermann negative.

Present illness began three months ago with the gradual onset of

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increasing constipation, epigastric pain not radiating and with flatulence. Gradual loss of weight and strength. No blood in stools.

One month ago had a more severe attack of pain with nausea and vomiting and was thought by her physician to have appendicitis.

Three days ago she had another attack of sharp pain in the right side of the abdomen with vomiting.

Physical examination on admission: Temperature, 98° F.; pulse, 80; leucocytes 10,200, with 70 per cent. polynuclears; hæmoglobin, 72 per cent.

The lungs gave no definite physical signs of tuberculosis but the X-ray of the chest was suggestive of pulmonary tuberculosis.

The heart showed a mitral stenosis.

Abdominal examination revealed a readily palpable rounded nodular mass in the region of the cæcum, only slightly tender, and which could be swung from side to side. Owing to the thinness of the abdominal walls, this tumefaction was visible at times, as was also peristalsis.

X-ray examination after a barium enema showed that the cæcum did not receive the injection and there was the appearance of gas at the hepatic flexure.

Operation by Dr. E. H. Pool, October 22, 1919, for ileo-cæcal tuberculosis. Right rectus incision. There was no increase of free fluid and the intestines and peritoneum seemed normal everywhere except in the cæcum.

The cæcum was the site of a firm, almost hard, rounded, nodular mass about 8 cm. in diameter, which very closely simulated a carcinoma, even when inspected after removal.

The cæcum and about 20 cm. of the ileum were resected and an end-to-side ileo-colostomy performed into the transverse colon.

*Pathological Report.*—Tuberculosis of the cæcum, with much chronic productive inflammation and scattered tubercles.

*Post-operative Notes.*—There was considerable drainage from the wound but the convalescence was satisfactory and the patient left the hospital in good condition, four weeks after operation.

February 6, 1920, this patient is shown by Doctor Pool before the New York Surgical Society, in good physical condition and without symptoms.

*CASE V.*—*Chronic hyperplastic tuberculosis of ascending colon. Tuberculosis of peritoneum. Operation. Cæco-colostomy by lateral anastomosis. Temporary improvement. Died about 4 months after operation.*

Lena R., Russian woman, aged twenty-seven years. Admitted to the New York Hospital, August 16, 1919. Discharged improved, September 1, 1919.

Chief complaint: Cramp-like pain in the right lower quadrant.

Past history of constipation for a number of years. Has had no serious illnesses. Has had several children and at present is nursing her three-month-old baby.

Present illness began two weeks ago with sudden cramp-like pain in the right lower quadrant of the abdomen, non-radiating. Constipation has been obstinate and she has vomited.

Physical examination on admission: Temperature, 98.4° F.; pulse, 84; leucocytes 6000, with 50 per cent. polynuclears.

Heart and lungs clear

Abdomen soft, relaxed. Cæcum feels as if dilated and filled with faeces, but is partially reducible on massage, with the accompaniment of much gurgling and borborygmi.

Operation by Dr. F. W. Bancroft, August 18, 1918: Upon opening the abdomen much straw-colored free fluid was encountered and everywhere the peritoneum was studded with tubercles.

On the ascending colon near the hepatic flexure there was a large, hard, nodular mass formed by the great thickening of the walls of the bowel, and encroaching on the lumen so as to cause partial intestinal obstruction.

On account of the patient's poor general condition and because of the complicating tuberculous peritonitis, resection was considered inexpedient.

A side-tracking anastomosis was performed by means of a lateral anastomosis between the cæcum and the transverse colon.

The appendix vermiformis was removed, and the wound closed.

*Pathological Report.*—Chronic inflammation of the appendix.

*Post-operative Notes.*—The convalescence was very easy and the patient left the hospital improved on the fourteenth day after operation.

*Follow-up Notes.*—Six weeks after operation the patient was readmitted to the hospital suffering with symptoms of chronic intestinal obstruction, with abdomen distended and of doughy consistency.

X-ray examination after a barium meal showed evidence of much kinking and adhesions in the small intestines.

The patient went home without operation and rapidly lost ground, and died about four months after operation.

*CASE VI.*—*Chronic hyperplastic tuberculosis of ileum. Enteroperitoneal tuberculosis. Perforated ulcer. Operation. Resection of 15 cm. of ileum. Ileo-colostomy. Recovery.*

Ellen V., Greek woman, aged twenty-six years. Admitted to Bellevue Hospital June 25, 1913. Discharged improved, August 11, 1913.

Chief complaint: Pain in right lower abdomen with vomiting.

Past history: Was well until two years ago, when after her arrival in America, she began to lose weight and strength. Has had no definite pulmonary symptoms. Her appetite and bowels are normal.

Present illness began two months ago with an attack of moderately severe pain in the right lower quadrant of the abdomen with nausea and vomiting.

Similar attacks have occurred several times in the past two months, the last one beginning four days ago.

For four days she has been confined to bed. No blood in stools.

Physical examination on admission: Temperature, 101° F.; pulse, 96; respiration, 24; leucocytes, 21,000, with 80 per cent. polynuclears.

Heart and lungs negative.

Abdominal examination reveals a palpable mass in the right lower quadrant, which is moderately tender and fixed.

Operation by Dr. Seward Erdman, June 27, 1913: Right rectus in-

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cision. A mass the size of a fist was found in the right inguinal region made up of matted loops of terminal ileum and cæcum, forming the walls of a fecal abscess at the site of a perforated tuberculous ulcer in the lower ileum.

For several inches distal to the perforation, the ileum was very much thickened and the lumen almost completely occluded.

The appendix vermiformis also was much thickened, but the cæcum was nearly normal.

About 15 cm. of the diseased ileum were resected and a side-to-side ileo-colostomy performed, using the transverse colon.

The appendix also was removed.

*Pathological Report.*—Chronic tuberculosis of the ileum and appendix. The section of ileum presented a perforated ulcer, and distal to this there was very marked diffuse tuberculous hyperplasia of the walls.

*Post-operative Notes.*—There was considerable drainage from the wound but it was never fecal. The patient was discharged improved, six weeks after operation.

*Follow-up Notes.*—The wound was finally completely healed in three months after operation.

Nine months after operation, the patient was shown before the Surgical Section of the New York Academy of Medicine in very fair general condition. Soon after this time she returned to Greece and has not been heard from.

*Tuberculosis of the intestines* is encountered in four different types, according to the classification of the French school:

1. The ulcerative type, or tuberculous enteritis, which is a common and often primary lesion in children; also occurs as a secondary lesion in adults with advanced pulmonary tuberculosis. (Weigert asserts that it is found in 90 per cent. of advanced tuberculosis.)

This type is not generally regarded as a field for surgery, although E. Archibald, of Montreal ("American Review of Tuberculosis," Baltimore, 1917), does advocate operation in many of these cases and reports a series of cases, some of which were benefited by resection or by side-tracking anastomosis.

2. The cicatricial or stenosing type. This results from contracture of the completely healed ulcer and produces a narrow fibrous stricture, giving the appearance of a ligature tied about the bowel. Its site is usually in the small intestine, and it may be multiple. When present in the large intestine, it never causes real obstruction, but at most only a shelf-like projection into the lumen.

3. The entero-peritoneal type selects the ileo-cæcal region and it combines ulceration with hyperplasia of the intestinal wall, and further, it involves the adjacent peritoneum, mesentery and lymph-nodes. It forms a tumor by the matting together of loops of bowel, and fecal abscess resulting from perforation of an ulcer is not uncommon. Occasionally a spontaneous entero-enterostomy takes place between adjacent loops of intestine.

4. Chronic hyperplastic tuberculosis, which according to Hartmann con-

stitutes 85 per cent. of all tuberculosis of the intestines in adults, is the fourth type. It is essentially a disease of the cæcum but is also found in the terminal ileum, the flexures of the colon and in the rectum.

In our series of cases, the first four were of the hyperplastic type; the fifth combined the hyperplastic type with general tuberculosis of the peritoneum, and the sixth case combined the hyperplastic with the entero-peritoneal type.

The distinctions between these four types are not always sharply drawn.

*Etiological Factors.*—Age. In our series of cases of chronic hyperplastic tuberculosis of the intestines the average age was just under thirty years, which is in harmony with the statement that it is most common between twenty and forty years. This fact is of some weight in differentiating tuberculosis from carcinoma.

Whether ileo-cæcal tuberculosis may be primary or whether it is always secondary to pulmonary tuberculosis is a question upon which opinions vary.

Cumston says that "the hyperplastic type is usually, one might say always, primary."

Hemmeter believes that it is always secondary to pulmonary tuberculosis.

That tuberculous infection may occur primarily in the intestinal tract is supported by incontestible autopsy evidence, and although comparatively rare in the adult (*i.e.*, from 1 to 3 per cent.), it is so found in from 17 per cent. to 37 per cent. (Heller) in infants and young children, but here the usual lesion is either tuberculous entero-colitis or tuberculous peritonitis and not the hyperplastic type.

The greater frequency in childhood has been attributed to the ingestion of milk from infected cows, to the habit of picking up contaminated objects and putting them into the mouth, but probably still more important is susceptibility to entero-colitis and acute infectious diseases which may leave a receptive mucous surface.

August J. Lartigau, in 1901, in a very thorough study of a case of hyperplastic tuberculosis, with most exhaustive autopsy, was convinced that the intestinal lesion was primary in his case.

In our own series of six cases, four had definite signs of pulmonary tuberculosis, although in no case was the lesion found to be very active.

With the aid of the X-ray examination of the lungs, it is probable that a pulmonary lesion will be more frequently recognized.

The mode of infection may be either indirect, where the bacilli are borne by the blood or lymph from a lesion elsewhere, the lungs or the mesenteric lymph-nodes; or direct, through the mucosa from ulcers on its surface.

This direct method may apply not only to the primary cases but also to those which are secondary to pulmonary tuberculosis where sputum, laden with tubercle bacilli, is often swallowed by the patient.

Food stagnation with attendant injury to the mucosa must be a factor of real determining import in the hyperplastic type, for this form is found in the three areas of stagnation, to wit, lower ileum, cæcum and rectum.

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*Pathology.*—The characteristic pathology of the hyperplastic tuberculosis is that of a massive thickening of the intestinal wall, especially involving the submucosa and the subserous layer. It represents the peculiar reaction of the lymphoid tissues against tubercular toxins of a lessened virulence.

The slow-growing, nodular tumor, situated usually in the right iliac fossa, may attain a size of from 8 to 20 cm. in diameter.

Its consistency is hard and presents a bossed surface, so that macroscopically it may very closely simulate carcinoma.

The tendency is to stenosis and chronic obstruction, due to encroachment on the lumen by the greatly thickened walls.

The appendix vermiformis often remains free from the tuberculous process, but it is usually buried in adhesions.

Frequently there is an adherent envelope of sclerosed adipose tissue (Hartmann and Pilliet), and upon raising this envelope the cæcum becomes visible, enlarged, indurated, dull red and vascular, but in general preserving its shape.

Tubercles are few and scattered or may be entirely absent. Usually the whole circumference of the cæcum is involved.

The mucosa is thickened, with uneven surface and polypoid projections, and except very early, or in rare cases, ulcers are found.

The submucosa is the seat of the earliest and greatest hyperplasia and tubercles and giant cells are most frequently found here.

The muscle coats are little affected or appear hypertrophied by infiltration with connective-tissue cells.

The subserous layer, like the submucosa, is markedly thickened and the great increase of fibrous tissue here contributes largely to the rigidity of the mass.

The peritoneum overlying is much thickened and reddened and the mesenteric lymph-nodes are practically always enlarged.

The stenosis is rarely annular but more often cylindrical or funnel-shaped and the cavity of the cæcum may be almost obliterated; in general, the obstruction is dependent on the length and tortuosity of the diminished lumen.

Complications may develop later in the disease, and among these tuberculous peritonitis is at all times a danger; perforation may occur above the stenosis (as in our Case VI).

Acute obstruction is very rare, as is also intussusception.

Fistula formation or entero-anastomosis may follow perforation.

General miliary tuberculosis may supervene, or a sepsis from mixed infection.

*Symptoms.*—The onset of the disease is slow and insidious, and it is estimated that it is usually from one to three years before the gradually increasing stenosis directs attention to the local lesion and leads the patient into the hands of the surgeon.

Early symptoms are indefinite gastro-intestinal disturbances, frequently with alternating constipation and diarrhœa.

Fever is usually absent and loss of weight and strength only occur late in the disease, unless due to pulmonary or other complications.

Pain marks the beginning of real stenosis and assumes a violent colicky character following the ingestion of food, sometimes immediately, but more commonly after an interval of two to three hours.

The pains last from one to several minutes and may be repeated many times during the process of digestion, and are usually referred to the right lower quadrant, whence they radiate across the abdomen.

"Ballooning of the intestines, visible peristalsis, clapotage, borborygmi, accompanying the colic and with the appearance of an elongated tunefaction, make up the syndrome of Koenig."

Vomiting is rare and never fecal; the stools occasionally show occult blood, and more rarely tubercle bacilli and pus.

In our series of cases the average duration of symptoms noted by the patient was only three months, and in each case this probably corresponded with the development of the definite stenosis.

*Diagnosis.*—Carcinoma of the cæcum is very frequently confused with hyperplastic tuberculosis and the differential diagnosis may finally have to rest with the pathologist.

Lartigau believes that some of the earlier reports of resection of the cæcum for carcinoma, with no recurrence, have in reality been cases of hyperplastic tuberculosis.

In such a differential diagnosis the main supports of a diagnosis of hyperplastic tuberculosis will be the earlier age of the patient, the slower growth and longer course (two to three years); absence of cachexia until late; lower leucocyte count; evidence of tuberculosis in the lungs or elsewhere; and rarely tubercle bacilli in the stools.

Appendicitis, subacute, or fibrinous or with abscess, is the diagnosis strongly suggested in those cases which give only a brief history of a few weeks, with pain in the right side, vomiting and palpable mass. In our series this was the diagnosis of the admitting physician, in three out of the six cases.

Diverticulitis or carcinoma of the sigmoid may be the provisional diagnosis in those cases of hyperplastic tuberculosis of the sigmoid.

Chronic intussusception, impacted feces, fibroma, sarcoma and actinomycosis must also be considered in making the diagnosis. As an aid in diagnosis the X-ray of the intestinal tract is of great value in locating the lesion, its extent, and in showing the amount of stenosis.

In the hyperplastic type, the X-ray picture is that of a filling defect which, however, cannot be differentiated from neoplasm.

In Case No. 4 of our series, the significant feature in the X-ray plate taken after the barium enema is the inability of the barium to enter the ascending colon and cæcum, for it met its obstruction at the hepatic flexure.

Recently, however, Pirie, also Lawrason Brown, have shown that even without real stenosis, *i.e.*, in simple ulcerative tuberculous colitis, filling defects are to be observed in the diseased areas.

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Brown states "that in all stages (of ulcerative tuberculous colitis) the barium meal shows shadows which determine definitely the presence of colonic ulcers; the X-ray picture is due to hypermotility and spasm or filling defects; such a picture in a patient with pulmonary tuberculosis denotes tuberculous colitis."

In our series of six cases, the location of the lesion of hyperplastic tuberculosis was: Ileum (alone), one case; ileum and cæcum, one case; cæcum or ascending colon (alone), two cases; cæcum and rectum, one case; sigmoid, one case.

*Treatment.*—The treatment is definitely surgical as soon as the diagnosis is established, which usually means that stenosis is already present; and the earlier the intervention, the better the prospect of a radical cure.

Radical resection of the diseased area is the operation of choice with appropriate intestinal anastomosis.

In the usual location, ileo-cæcal, the operation will consist in resection of the cæcum and as much of the ileum as may be necessary and the performance of an ileo-colostomy, using the transverse colon, by preference, and a side-to-side anastomosis.

When the patient's general condition prohibits a radical excision, or where the local technical difficulties are too great, some other surgical expedient must be used to overcome the obstruction, but none of these is really curative.

1. Partial exclusion is the simplest and safest procedure as a palliative treatment and consists in a simple side-tracking lateral anastomosis between afferent and efferent loops of intestine; such was the procedure of choice in Case V of our series.

2. Unilateral exclusion affords more complete rest to the diseased area.

3. Bilateral exclusion has obvious disadvantages, even if a colostomy be performed in the isolated segment to permit of its proper drainage.

4. An artificial anus in the afferent loop must be considered only as a measure of last resort.

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## THE RESULTS OBTAINED IN THE TREATMENT OF CHRONIC ARTHRITIS BY THE REMOVAL OF A DISTANT FOCUS OF INFECTION

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THE term focal infection in the last decade has become a byword in most of the clinics of this country. A focal or confined infection is an infectious process confined to some organ or tissue constantly maintaining bacteria of greater or less virulence. From this focus bacteria or toxins may be absorbed which produce disease processes, either local or general, in some other part of the body.<sup>1</sup>

The teeth, the tonsils, the genito-urinary tract, the sinuses, the bronchi, the gall-bladder, the gastro-intestinal tract, the pancreas and the vermiform appendix are the usual locations for such foci.

The organisms most frequently found in such foci are the streptococci, gonococci, staphylococci and pneumococci.

The disease processes which are believed to be due to these foci of infection are numerous, namely, chronic arthritis,<sup>2</sup> nephritis,<sup>3</sup> gastric ulcer,<sup>4</sup> herpes zoster,<sup>5</sup> endocarditis,<sup>6</sup> myocarditis,<sup>7</sup> pancreatitis,<sup>8</sup> iritis,<sup>9</sup> skin diseases,<sup>10</sup> diabetes,<sup>11</sup> hyperthyroidism,<sup>12</sup> septicæmia,<sup>13</sup> and many others.

In many of the later diseases, the relation to infection is of rather recent origin, while the relation of arthritis to infection is comparatively old.

Bradford,<sup>14</sup> in 1883, had three cases of so-called rheumatic arthritis of the spine. Two of these had a gonorrhœal history. Schüller,<sup>15</sup> in 1892, found organisms in cut sections of tissues, which he described in 1893.<sup>16</sup> In 1896<sup>17</sup> he described a quick method for demonstrating organisms in human tissues.

Poynton and Paine,<sup>18</sup> in 1900, described a focal infection, as a localization of infection with outpouring of toxins which causes carditis, arthritis, nodules and other lesions.

Coincident with the theory of focal infection has arisen the idea of eradication of the foci, and thus checking or curing the disease.

This paper deals with the results obtained in the treatment of chronic arthritis by the removal of foci of infection.

Few accurate reports have been made of the results of this method of treatment. Billings<sup>19</sup> reported a series of 10 cases of chronic arthritis, treated by the removal of foci of infection. Eight of these gave excellent results. In two of the very advanced cases the streptococci obtained from the foci, when injected into rabbits, produced an acute arthritis, either single or multiple.

Billings,<sup>20</sup> again in 1913, reported 70 cases of the so-called deforming type of arthritis. Although he gave no definite percentage as to the number

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in which good results were obtained, he stated that in those patients in whom no marked destruction of tissue had occurred, recovery took place in many, and others were at the time convalescing. He also stated, that patients with bone and cartilaginous disease had vastly improved, and that the progress of disease apparently had been checked.

Ivy<sup>21</sup> reported 8 cases of so-called arthritis deformans occurring between the ages of twenty-five and fifty years. In all these cases the focus was situated in the teeth. Root extraction and treatment of the pyorrhœa was followed by marked results in six of the cases.

Crowe, Watkins and Rothholz<sup>22</sup> removed the tonsils in many cases of infectious arthritis and so-called rheumatoid arthritis. In 31 cases of infectious arthritis of a chronic nature, which they were able to follow up, 24 cases had normal joints, both subjectively and objectively. In some the affected joints had become worse for a few days immediately after operation, but began to improve in two to three weeks. Often it required from six to eight months before all joint symptoms had entirely disappeared. Four cases were classified as improved, because the patients were able to walk without pain. The affected joint, however, had never entirely cleared up, and after operation had at times been worse. Two cases were not improved, and one was worse than before the operation. In the so-called rheumatoid arthritis they were able to follow up nine cases only. Two of these had improved, but this improvement might have been due as much to the general hygienic measures which they followed as to the tonsillectomy. Two cases were not improved, but no new joints were involved. Five of the nine were much worse, new joints having become involved, and they were for the most part helpless.

He concluded from this group of cases that, only in very exceptional circumstances, should any one subject a patient with rheumatoid arthritis to an operation for removal of tonsils, even in cases that give a history of repeated attacks of tonsillitis for many years.

For the past three years patients with chronic arthritis coming to the Stanford University Clinics have been treated on the theory, that every case of chronic arthritis, as of acute arthritis, is due to an infection or to trauma.

The majority of these patients were seen by Doctor Ely in the Orthopædic Clinic. The Clinic Procedure was as follows: A very careful history was taken, and a physical examination was done on each patient. In most cases routine laboratory examination of blood and urine was done. A large number of X-ray examinations and blood Wassermann tests were made.

Special attention was paid to the history of Neisser infection, when treated, how treated, and the length of time treated. Also whether or not the patient had been subject to repeated attacks of sinusitis or tonsillitis. The history of pyorrhœa, root abscesses, and chronic mouth infections was carefully taken up.

In the physical examination, particular attention was paid to the teeth, nasal sinuses, the tonsils, and the genito-urinary tract. When a patient gave

a history of repeated attacks of tonsillitis, and the physical examination showed evidence of chronic tonsillitis, he was not immediately rushed over and subjected to a tonsillectomy, but was carefully examined for other foci of infection. If none was found, then the tonsils were treated as the source of infection.

In many cases a number of foci were found, such as chronic prostatitis and chronic tonsillitis, or chronic prostatitis and root abscesses or pyorrhœa.

After the existence of the focus had been established as well as possible, each case was referred to its respective clinic, that is, the genito-urinary, the dental, or nose and throat, and was treated there. (Treatment to be described later.)

During the treatment and for a considerable length of time afterwards, these patients were followed up and watched by Doctor Ely.

From the card index and catalogue system of the History Room and with the aid of Doctor Ely, the histories of 125 cases of chronic arthritis were obtained. These did not include acute or subacute cases, but only cases in which the arthritis had existed over a period from months to years.

These histories were segregated into treated and untreated cases, and after careful study had been made of the treated cases a special endeavor was made to see personally as many of these patients as possible. In this way a personal interpretation of the results of the treatment can be given.

Of the 125 selected cases only 66 cases were treated, and of the 66 cases 21 were seen personally and the results recorded. Therefore the results of the clinicians in 66 cases and the results of the 21 cases seen by me personally will be given separately. These cases are classified and subdivided according to the mode of treatment and the situation of the focus. The accompanying charts tabulate only the treated cases.

Thirty-three treated cases in which the primary focus was believed to be located in the genito-urinary tract.

Twenty-six cases in which the primary focus was believed to be located in the teeth.

Seven treated cases in which the focus was believed to be located in the tonsils.

*Cases in Which the Primary Focus was Believed to be in the Genito-Urinary Tract.*—The total number of cases in this class were 45. Of this number, 97.5 per cent. were men and 2.5 per cent. women. The decades in which chronic arthritis was most prevalent in this series are:

| Years      | Cases   | Per cent. |
|------------|---------|-----------|
| 20-30..... | 22..... | 48.4      |
| 30-40..... | 14..... | 30.8      |
| 40-50..... | 6.....  | 13.2      |
| 50-60..... | 2.....  | 4.4       |
| 60-70..... | 1.....  | 2.2       |
|            | —       | —         |
|            | 45      | 100       |
|            | 650     |           |

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Thirty-three cases received treatment in the genito-urinary clinic. This consisted of prostatic massage, and massage of the vesicles, when indicated. This was done usually twice a week. Hot permanganate injections, urethral dilatation, mixed Neisser vaccine and silver nitrate instillations constituted the treatment in general. In four cases vesiculotomy was performed. All these patients were advised to rest as much as possible. In some cases baking, belts, braces and other supports were resorted to.

Of 33 cases which received treatment, 42.3 per cent., according to clinical observation, showed definite improvement. This improvement manifested itself in the loss of pain, the increased amount of motion in the joints, and the ability to get about and to go back to work; 15.75 per cent. of the cases showed no signs of improvement. In 40, 95 per cent. of the cases, we were unable to secure data.

Eleven cases were seen personally. Of this number ten showed definite improvement. One showed no sign of improvement after a long period of treatment.

The following are a few of the cases in which striking results were obtained:

CASE IX.—J. B., cigar clerk, complains of rheumatism for five years. This began in his right shoulder, as a hot stinging sensation. Two months later his left shoulder and right knee became involved.

*Family History.*—Neisser infection in 1909, also a chancre shortly after this. Salvarsan three times. Catarrh of the nose all his life. Teeth and tonsils have never given him any trouble.

*Physical Examination.*—Heart and lungs are negative. All the joints are swollen, especially the knees. The patient walks on crutches. Motion in all joints is limited. He has pyorrhœa and very poor teeth. His prostate and seminal vesicles are enlarged and tender. Prostatic secretion contains many pus cells. Discharge from the meatus. No Neisser organisms were found. X-ray shows a chronic arthritis of both knees, with some new bone formation. Wassermann was negative.

*Diagnosis.*—Arthritis, chronic multiple; prostatitis, chronic; vesiculitis, chronic; urethritis, chronic; pyorrhœa alveolaris.

This patient was treated for a period of five months. The treatment consisted of hot permanganate injections, prostatic massage and finally the vesicles were drained.

Ten weeks after treatment was started this patient was seen walking along the street with a cane. All his joints were less swollen, and he was greatly improved. This patient was watched for over six months, and was seen to improve steadily. At the end of two years he was again seen. At this time all his symptoms had disappeared and he was practically well. Two and one-half years after treatment was begun, the patient was again seen, and he was perfectly well, and had never had any recurrence of his symptoms.

CASE X.—Mr. C., time clerk, complains of soreness and swell-

ing of the right wrist and fingers of the right hand. Feet are tender and flat. He also has a slight sore throat.

*Past History.*—Rheumatism in both ankles in 1884. Typhoid in the same year. Neisser infection four times. Three of these were cured in a few weeks, but the last one lasted over a month. At times the patient had rheumatism so badly that he was unable to raise his hand to his mouth to feed himself.

*Physical Examination.*—Heart and lungs are negative. Both feet are flat. Left ankle is swollen and immobile. Right wrist is painful on motion. Motion is restricted in all directions in this joint. The left wrist and the metacarpophalangeal joints are painful. He has a few bad teeth. Prostate is large and the secretion contains pus. He has chronic urethritis and tonsillitis. X-ray shows an unerupted third right upper molar. Wassermann negative. Hæmoglobin, 89 per cent. Albumen in the urine in a light cloud.

*Diagnosis.*—Arthritis, chronic multiple; urethritis, chronic; prostatitis, chronic; vesiculitis, chronic; tonsillitis, chronic.

The patient was put through a vigorous course of treatment in the genito-urinary clinic. This consisted of massage, hot permanganate injections, sounds and urotropin. At the end of one month his hands were practically well. His feet were much better, but he still had some pain in them. At present he is able to walk comfortably and to work, which he was not able to do previous to treatment. Two months after treatment he was practically well.

In these cases in which the focus is situated in the genito-urinary tract, in order to obtain definite improvement it is essential that the patient undergo a long-continued treatment. Complete eradication of the focus is necessary. The results in these cases where the treatment has been thorough are permanent, as shown in Case IX. In this case the patient has been well for over two and one-half years.

Cases in which the primary focus was believed to be located in the teeth.

In the last one and one-half years the clinicians at Stanford have laid greater stress upon the teeth as locations for foci of infection. This is evidenced by the fact that 49.6 per cent. of the cases in this series are placed under this division.

Of 62 cases of chronic arthritis believed to be due to the foci of infection in the jaws, 72.5 per cent. were men and 27.5 per cent. women. Thirty-two per cent. of the cases occurred between the ages of forty and fifty years.

| Years      | Cases   | Per cent. |
|------------|---------|-----------|
| 20-30..... | 4.....  | 6.44      |
| 30-40..... | 16..... | 25.76     |
| 40-50..... | 20..... | 32.20     |
| 50-60..... | 14..... | 22.54     |
| 60-70..... | 8.....  | 12.88     |
|            | —       | —         |
|            | 62      | 100       |
|            | 652     |           |

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It is of interest and an important fact to note that over 54 per cent. of the cases occur between the ages of forty to sixty years. This about the stage of life when decayed teeth and root abscesses are most prevalent.

Twenty-six cases were treated, and this treatment consisted in scraping the teeth, removing the salivary calculi, filling in many cases, opening and draining root abscesses, extraction of roots and treatment of pyorrhœa.

**CASE V.**—Mrs. V., aged sixty years, Hungarian housewife, complains of pain in the right knee. This is increased on motion. Duration, four years. Some swelling the last four months.

*Past History.*—No trauma. Gall-stone operation in 1912. Polyp removed from the nose at about the same time. Rheumatism in 1901. Pyorrhœa for a long time.

*Physical Examination.*—Some swelling at the head of the tibia. No redness or tenderness. No restriction of motion. Some grating. Marked pyorrhœa. X-ray shows some new bone growth about the head of the tibia and the lumbar vertebræ. Also an unerupted molar.

*Diagnosis.*—Arthritis, chronic of spine and knees; oral sepsis; pyorrhœa alveolaris.

*Treatment.*—Teeth extracted. Pus drained. Pyorrhœa treated. Baking and massage. This patient received five treatments in three weeks. She was watched carefully over a period of eight months. Almost immediately after treatment was instituted the pain and swelling became less. Motion was no longer restricted, and she was practically well.

**CASE XXIV.**—Mr. F., motorman, aged fifty-four years, complains of stiffness in the knees for the last year. Pain when walking and when standing. At times a feeling of hot irons in the feet.

*Past History.*—General condition always excellent. No trauma. Neisser infection denied. No history of tonsillitis or infectious diseases.

*Physical Examination.*—Thickening and swelling of the right knee. Patella grates. Teeth poor. Bad pyorrhœa. Perforation of right drum. Otitis media. Blood bad, urine negative.

*Diagnosis.*—Arthritis, chronic of knee; pyorrhœa alveolaris; otitis media, chronic.

*Treatment.*—Lower cuspids extracted. Teeth scaled. Second molar extracted. Bier treatment. Treated three times.

Five days after the first treatment the patient was very much better. The swelling had decreased, and he was able to bear weight on the knee. The burning sensation in the feet had disappeared. Three months after treatment, the patient still continued to improve.

**CASE XII.**—Mr. S., Austrian iron worker, aged forty-nine years, complains of pain in the spine and lumbar muscles. This first followed an attack of constipation three years ago, and at the time lasted one week. Two weeks ago he had a similar attack of pain.

*Past History.*—Usually well. Four years ago was struck by an

automobile, and his head was slightly injured. Melancholia at times, otherwise the history is negative.

*Physical Examination.*—Heart and lungs are negative. Lumbar spine is stiff. Flexion is lost. There is a kyphosis at the eighth thoracic vertebra. Many bad teeth, and some pyorrhœa. X-ray shows considerable spurring of the thoracic spines. Hæmoglobin, 70 per cent. Albumen in the urine in a slight amount.

*Diagnosis.*—Arthritis, chronic, of the spine; oral sepsis and pyorrhœa.

*Treatment.*—Three lower molars were extracted. A large granuloma one-quarter of an inch in diameter was removed. Pyorrhœa treated. Teeth scaled. Spine strapped, and a belt fitted. Treated twice. Five days after treatment the patient was very much improved. Pain was much less severe. Four days after the second treatment the patient walked about one and one-half miles to the clinic. He stated, that before treatment he could never have done it on account of pain.

This class of patients differs considerably from those in the former division. In those, long-continued treatment was necessary to obtain improvement, while in these definite improvement is noticed in one treatment, and in a very few days after treatment. This is also in accordance with the findings in the clinic.

In this series 61.5 per cent. of the cases treated showed definite improvement. This evidenced itself by the disappearance of pain and swelling, and the regaining of lost function.

In 15.3 per cent. of the cases no signs of improvement were shown, and one seemed to be worse after treatment.

In 23.3 per cent. of the cases we were unable to obtain data.

Eight cases were seen personally. Four of these showed definite improvement.

Cases in which the primary focus was believed to be located in the tonsils.

In this division there were 18 cases. All had a history of repeated attacks of tonsillitis. In this class 55 per cent. of the cases were women and 45 per cent. men. The age of incidence in this series is given below:

| Years      | Cases  | Per cent. |
|------------|--------|-----------|
| 10-20..... | 3..... | 16.66     |
| 20-30..... | 2..... | 11.11     |
| 30-40..... | 3..... | 16.66     |
| 40-50..... | 3..... | 16.66     |
| 50-60..... | 5..... | 27.77     |
| 60-70..... | 1..... | 5.5       |
| 70-80..... | 1..... | 5.5       |
|            | 18     | 100       |

In only seven of these cases was treatment given, and this in all cases consisted of tonsillectomy. Of the seven cases, according to clinical observation, 4 showed marked improvement.

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CASE II.—Mrs. J., Swedish housewife, May 29, 1915, complains of pain in the bones and joints, for the past seven months. Fingers, wrist, back and shoulders are painful and stiff.

*Past History.*—Has had measles, mumps and whooping cough. Five years ago she had a tonsillar abscess. Has had swelling of the feet and ankles since 1914.

*Physical Examination.*—Heart and lungs are normal. The hands, left elbow, left shoulder and right foot are swollen and tender. Tonsils are hypertrophied and covered with a thin exudate. Nose is negative. X-ray shows demineralization of the bones of the right elbow and shoulder. Marked synovial thickening at the wrist.

*Laboratory Reports.*—Blood, hæmoglobin, 65 per cent. Urine, a light cloud of albumen.

*Diagnosis.*—Arthritis, chronic multiple; tonsillitis, chronic.

*Treatment.*—Patient was in bed almost one year. Sodium salicylate in large amounts was administered. Elimination by sweats and baking. June, 1915, the tonsils were removed. Three weeks after operation the patient showed marked improvement. Pain was less severe and the swelling in the joints had decreased. She is now walking, whereas before she was bedridden. Four months later she was still improving, the joints were much better, and the swelling had practically all subsided. She is now able to do some housework.

For eighteen months this patient was watched, and she showed marked improvement during this time. At the end of two years she was again seen. At this time she was not quite so well as she had been previously. She was up and around and able to do housework, but at times she had some pain in her joints.

CASE XX.—Mr. K., Russian painter, complains of pain in his feet and knees. This began insidiously about three weeks ago. For a long time previous to this the patient had pain in his left heel and ankle.

*Past History.*—Always healthy. Denies Neisser infection and lues. No sore throat or tonsillitis. He is constipated, and suffers from hemorrhoids.

*Physical Examination.*—The patient walks very stiffly. The left foot is abducted. The metatarsal joints of his left foot are painful on motion. He has several bad teeth. The tonsils are enlarged.

*Diagnosis.*—Arthritis, chronic, of knees and feet; tonsillitis, chronic.

*Treatment.*—Tonsillectomy. One week after treatment the patient stated that he had not suffered any pain since the operation. Motion is no longer painful.

Two cases of this series were combined with genito-urinary infections, and it was impossible to determine from what treatment they derived their benefit.

Two cases were no better after tonsillectomy.

Two cases were seen personally, and in these the results were very striking.

HERBERT S. CHAPMAN

SUMMARY

*Clinical Observations*

| Kind of cases        | No. of cases | Improved cases | Not improved cases | Not seen cases | Total cases |
|----------------------|--------------|----------------|--------------------|----------------|-------------|
| Genito-urinary . . . | 33           | 14<br>42.3%    | 5<br>15.15%        | 14<br>42.3%    | 33<br>100%  |
| Teeth . . . . .      | 26           | 16<br>61.5%    | 4<br>15.1%         | 6<br>23.2%     | 26<br>100%  |
| Tonsils . . . . .    | 7            | 3<br>42%       | 2<br>28.4%         | 2<br>28.4%     | 7<br>100%   |
| Total . . . . .      | 66           | 33<br>50%      | 11<br>16.66%       | 22<br>33.33%   | 66<br>100%  |

*Author's Observations*

| Kind of cases        | No. of cases | Improved cases | Not improved cases | Not seen cases | Total cases |
|----------------------|--------------|----------------|--------------------|----------------|-------------|
| Genito-urinary . . . | 11           | 10<br>30.3%    | 1<br>3.33%         | 22<br>66.66%   | 33<br>100%  |
| Teeth . . . . .      | 8            | 4<br>15.4%     | 4<br>15.4%         | 18<br>69.2%    | 28<br>100%  |
| Tonsils . . . . .    | 2            | 2<br>28.48%    | 0<br>00            | 5<br>78.60%    | 7<br>100%   |
| Total . . . . .      | 21           | 16<br>24.2%    | 5<br>7.6%          | 45<br>68.20%   | 66<br>100%  |

CONCLUSIONS

1. Fifty per cent. of the cases of chronic arthritis treated at the Stanford University Clinics by the removal of foci of infection, according to clinical observation, showed definite improvement.

2. From personal observation of 21 cases, the following was concluded: (a) 76.2 per cent. of the cases showed definite improvement; (b) 19.0 per cent. showed no improvement or change; (c) 4.8 per cent. were worse after treatment.

3. Although the percentage of improvement did not vary greatly in the different groups, the most striking results were obtained in those cases in which the focus was situated in the genito-urinary tract.

4. Long-continued faithful treatment is necessary before improvement can be expected in the cases in which the focus is located in the genito-urinary tract.

5. Very rapid recovery with very few treatments was obtained in those cases in which the teeth were the seat of infection.

6. Removal of the tonsils in several cases was followed in a few days by loss of pain, and later by return of function to the injured joint.

7. The compilation of these statistics was made possible through the kind assistance of Drs. Ely, Hewlett, and Williams, also through the aid of the staff of the history room.

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## INJURIES OF THE SEMILUNAR CARTILAGES OF THE KNEE-JOINT

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THE semilunar cartilages are fibro-cartilaginous structures placed within the knee-joint to deepen the cavity for the reception of the condyles of the femur. They are wedge-shaped with their apices to the center and their bases to the periphery of the joint. Their presence allows a more even distribution of the wear and tear on the joint surfaces than would otherwise be the case. The external cartilage is less intimately associated with the capsule of the joint, and being more free it can readily slip from the grasp of the external condyle and the external tuberosity of the tibia. It is thicker, broader, and more nearly circular than the internal cartilage, and on this account we find the area of contact between the external condyle of the femur and the external tuberosity of the tibia less extensive than the contact on the inner side of the joint. The internal cartilage, at its periphery, is closely adherent to the capsule and internal lateral ligament and thus is not permitted the laxity and consequent ability to glide out of harm's way that the external cartilage enjoys. It is not so thick as the external cartilage and is more crescent shaped than circular. The internal condyle of the femur crowds it more than does the external condyle the outer cartilage.

In the past we have been prone to speak of a loose semilunar cartilage as being the cause of a mechanical derangement of the joint. While it is possible that some derangements are caused by an internal semilunar cartilage that is abnormally mobile, there is no doubt that the vast majority of so-called derangements are in reality due to fractured or torn semilunar cartilages. This has been drawn to our attention repeatedly by Sir Rutherford Morison.

The history of a typical mechanical derangement of the knee due to an injury of the semilunar cartilage is clear cut as a rule. The patient is usually a male under 35, in the active period of life. The attack may have come on during some game or trial of strength. The exact manner of infliction of the injury may be a little clouded, but almost invariably the story is elicited that the knee was in moderate flexion and the foot or leg in external rotation. In this position the internal semilunar cartilage is placed the deepest in the joint. When extension is attempted, the internal condyle of the femur catches the cartilage and one of three things must take place to avert disaster; the force must be stopped, the cartilage must slip out of the grasp, or the cartilage must be firm enough

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to stand the pinching, crunching force inflicted on it. It is usually impossible to stop any such violent contraction of a muscle so powerful as the quadriceps in time to prevent injury, once the contraction is well established. The fibrocartilaginous structure will not readily withstand the extreme force to which it is subjected, and the cartilage usually rips or tears in its longitudinal axis; the condyle of the femur forces the detached portion to the mesial portion of the joint, and thus prevents extension, the knee being locked in partial flexion.

The subjective symptoms are severe pain and immediate disability, the patient is unable to use the knee, and often falls to the ground, grasping his knee with both hands. The pain is not due to the tear in the cartilage, since the semilunar cartilages are not supplied with nerves, but to the stretch on the ligaments. It may be necessary to aid the patient or even carry him to his bed, and, if reduction is not immediately made, the period of enforced quiet and disability will be prolonged and will depend entirely on the character of the tear or fracture present in the meniscus.

A distinct crack may be heard at the time of injury. Swelling and effusion follow and subside only after days. The cartilage may gradually, of its own accord, as it were, glide back into place; extension of the knee then becomes possible. Most of the pain is referred to the inner side of the knee just anterior to the internal lateral ligament at the joint-line. The patient may even feel a protuberance or swelling there, and in chronic cases with repeated locking, it may be quite noticeable, as the synovial effusion may not be so great in these cases of long standing as in early cases. The lump only appears at the time of locking and is always noted at the same spot. Patients often say the knee is dislocated. This statement given by an intelligent patient usually means one of three things, either a torn semilunar cartilage, a dislocated patella, or a loose osteo-cartilaginous body. If the semilunar cartilage is torn it is best, as hereafter described, that the cartilage shall be immediately reduced. Whether or not there is to be recurring locking depends largely on whether reduction is promptly done, whether the part is kept at rest long enough to permit of healing, and on the type of the tear in the meniscus.

By far the most common tear seen is the so-called "bucket-handle" tear of Morison (Fig. 1). It consists of a displacement inward of the torn middle three-fifths of the meniscus so that it lies mesially to the internal condyle. It is attached to the anterior one-fifth and the posterior one-fifth so that it effectually blocks complete extension. It is astonishing that this condition may exist in the chronic recurring cases and the patient still be fairly active and getting about very well after some months, the only symptoms being incomplete extension and occasional locking. There are other types of tears but in my experience this is the most common. The swelling and pain are often marked in the early locking, but as the attacks become more frequent, a certain

tolerance seems to be established, all symptoms being less marked. The patients complain of a feeling of insecurity and dread, however, that in itself greatly reduces their efficiency and may even keep the more timid from working.

If the recurrent trouble in the joint is due solely to injury to a semilunar cartilage there is no periarticular thickening, and if this thickening is present with a somewhat indefinite history the surgeon should be very slow to make a diagnosis of derangement due to a damaged semilunar cartilage. Periarticular thickening always means that arthritis is present. In fact, the presence of any residual symptoms or signs between attacks should make the surgeon very careful about making a positive diagnosis of an injured semilunar cartilage. The original trauma is often so sudden and the patient so disturbed that an incomplete history is given and it is only by careful extraction of the facts that a clear statement can be obtained. In a few instances I have been unable to get a history of anything that might be called a severe injury. The locking may have come on when the patient was walking, and, in one instance, locking occurred when the patient merely turned over in bed.

While the clear-cut case, as outlined, is easy of diagnosis there are other affections of the knee-joint which are more or less often confused with this condition that must be considered in the differential diagnosis. It would seem that tuberculosis of the knee would not present symptoms of this nature, but tuberculosis of the synovial type with its mild symptoms extending over a length of time is often confusing. There may be twinges or attacks of pain simulating locking of the joint which are caused by the fringes of thickened synovia being nipped between the joint surfaces, but the chronicity of the complaint with the periarticular thickening, persistent effusion, and the absence of severe locking are enough to put the surgeon on his guard. Also careful general examination will perhaps disclose another tuberculous focus in the body such as a pulmonary or genito-urinary lesion, which in itself, although not sufficient to corroborate a diagnosis of a tuberculous knee-joint, strengthens such a diagnosis. Some of the infectious arthritides may also be difficult of differentiation, but the catchings complained of are mild and periarticular thickening is also present.

The chief condition to be differentiated and the one producing nearly the same symptoms as a tear in the semilunar cartilages is the loose body caused by osteochondritis dissecans<sup>1</sup> (Fig. 2), hypertrophic arthritis (Fig. 3), or osteochondromatosis (Fig. 4). Clinically, the loose body may be felt, but unlike the semilunar cartilage it varies in its position and may be felt above the patella or to the outer or inner side of the joint. The locking may be quite as painful, but it is usually of shorter duration, and the swelling is rarely so great. In osteochondromatosis the bodies are generally quite numerous, and are easily to be felt at all times. The röntgenograph is the final court and will invariably show any osteo-

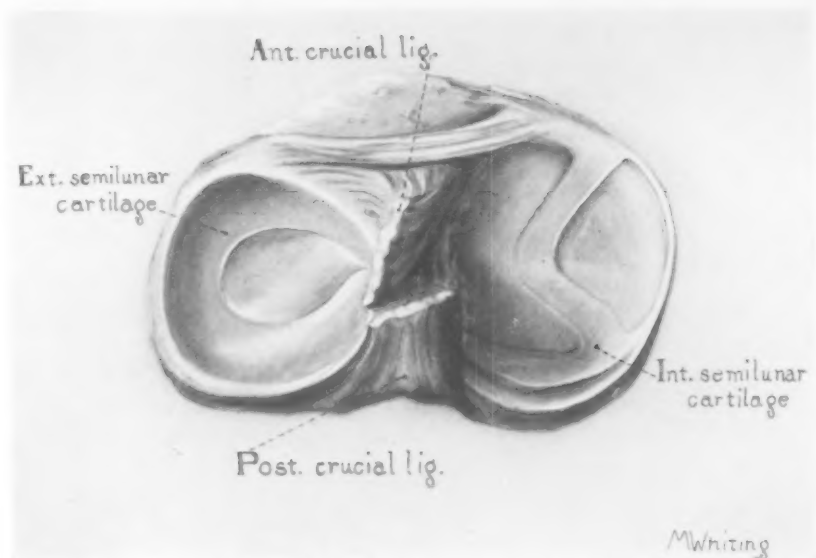


FIG. 1.—Internal semilunar cartilage displaced to the mesial portion of the joint; anterior portion blocking extension; called bucket-handle type by Rutherford Morison.



FIG. 2—Osteochondritis desiccans. Loose osteocartilaginous body lying at the site of origin.



FIG. 3.—Osteocartilaginous loose bodies due to hypertrophic arthritis.



FIG. 4.—Osteocartilaginous loose bodies due to osteochondromatosis.

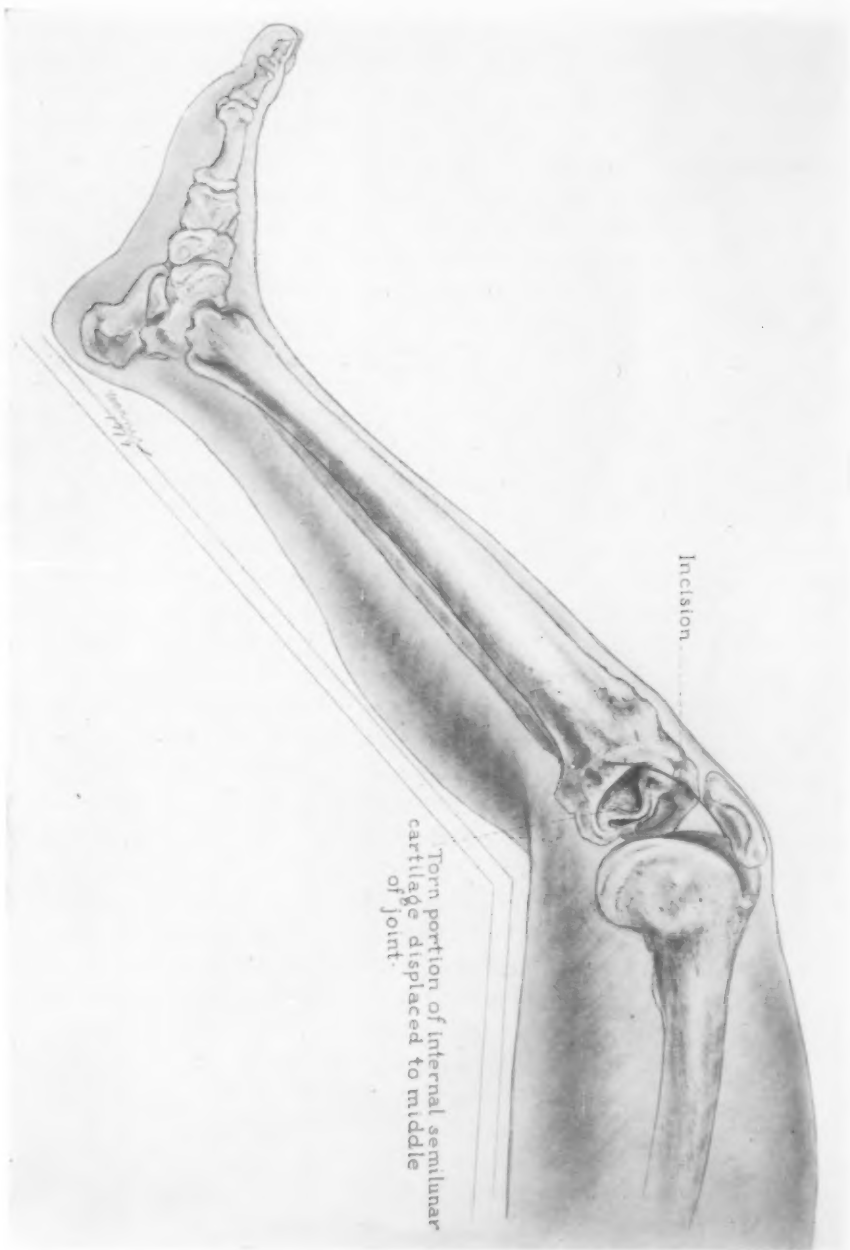
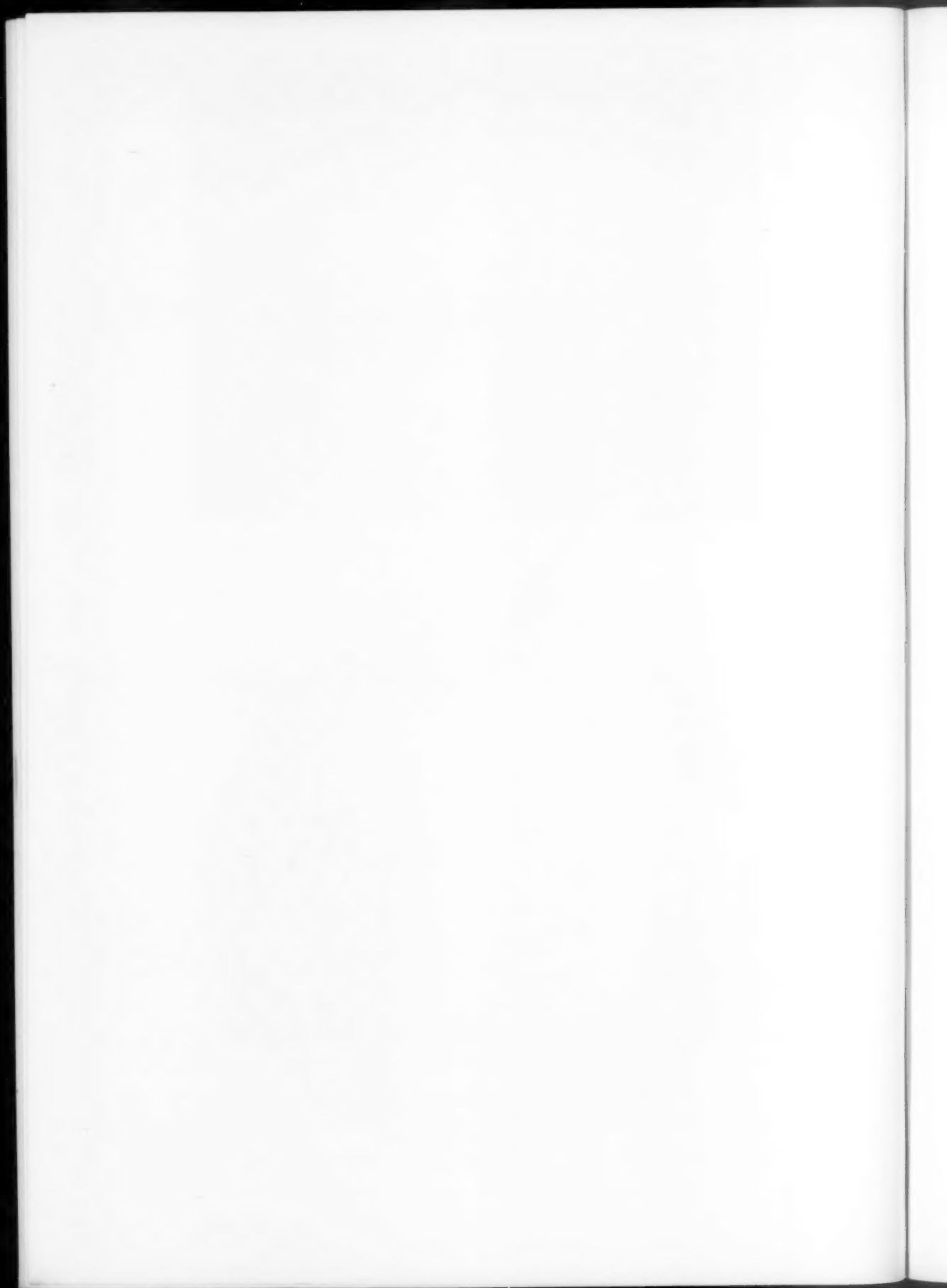


FIG. 5.—Incision used with leg flexed at an angle of 140 degrees.



## INJURIES OF THE KNEE-JOINT SEMILUNAR CARTILAGES

cartilaginous body. If in a patient having typical locking of the knee-joint a good series of röntgenograms show nothing, it may be concluded that the locking is due to a damaged semilunar cartilage and that the chances are about fifty to one that the offending meniscus is the internal.

In my discussion so far I have mentioned only the symptoms produced by the internal semilunar cartilage. The same general symptoms are present if the derangement is due to the external cartilage, but the manner in which the injury is received is not necessarily the same. I know of no typical position in which such damage takes place as is so well known regarding the injuries to the internal semilunar cartilages. The pain, however, is usually referred to the outer side of the joint and a restoration of even casual function is not apt to take place until the offending cartilage is removed.

If the surgeon is called when the first locking occurs he should, if possible, immediately reduce the torn or fractured cartilage. It is not generally necessary to give an anæsthetic as the patients are usually young, hardy, and vigorous and can well stand the pain incident to the reduction. It is best to place the patient on the floor, flex the knee to the limit, the thigh to well beyond a right angle and suddenly when the patient is off guard, with the thumb pressing over the anterior attachment of the cartilage, extend the knee. If the reduction is complete the patient will usually tell you that it feels better. If this assurance is lacking it should not be disregarded; the patient is usually right. If the reduction is complete, as indicated by complete extension of the joint, and the statement of the patient, the leg should then be put in a cast for at least four weeks. This may insure such healing that a recurrence will not develop. If reduction is impossible the joint should be opened and the cartilage removed. The difficulty is that it is not always possible to determine whether or not reduction is complete, and sometimes it is only after the period of fixation is over and the patient is permitted normal motion that the surgeon can say whether operative interference will be necessary. When there is no question that conservative measures will not accomplish reduction, the joint should be opened. In the other more doubtful cases operation should never be resorted to until after at least two clear-cut derangements or lockings have taken place. Both Sir Robert Jones and Sir Arbuthnot Lane make the statement that recurring locking may be an etiologic factor in the development of tuberculosis in such a knee. While their theory that chronic irritation is a possible factor in the development of tuberculosis is not usual, we must give heed to a statement by such eminent surgeons. The recent war has shown more positively than was possible to demonstrate in civil practice that the knee-joint has a very definite resistance to infection. If the knee-joint is accorded the aseptic respect shown the abdomen, no fear need be entertained regarding exploration of the joint. For a number of years I have not given the knee-joint any more preparation than

has been given the abdominal cases in the Mayo Clinic. When necessary the knee should be shaved the day before operation, but I do not hesitate to shave the leg on the operating table if it has been neglected previously. The ordinary benzine and iodine preparation is used, care always being taken to clean the knee both in the flexed and extended positions. The part is draped with sheets and towels in the usual manner, and a rubber tourniquet applied. This technic has been employed in considerably more than 100 cases and we see no need for any more extensive preparation.

The operative technic outlined by Sir Robert Jones has been more or less followed. After the patient is asleep he is placed in slight Trendelenburg position and the foot of the table is dropped so that the knee is in about 140° flexion. The triangular space bounded by the patella and patellar ligament, the head of the tibia, and the inner condyle of the femur, is readily outlined and may be opened by a curved or straight incision (Fig. 5). If there is no fracture or tear in the cartilage, the surgeon should be loath to remove the meniscus. A pathologic condition should be evident before any structures are removed. If exposure of the meniscus is difficult, the incision in the capsule may be enlarged, care being taken not to injure the internal lateral ligament; also if the foot is rotated outward and the leg everted with the knee still in the semiflexed position, a better view may be obtained. It is generally sufficient to remove a little more than the anterior three-fifths of the cartilage. It is well to leave a small rim attached to the capsule and thus no injury will be done to the ligament. The capsule should be closed in layers, plain catgut being used. The skin may be closed with non-absorbable sutures. A well-padded dressing is firmly applied before the tourniquet is removed. A plaster of Paris cast from the groin to the ankle is applied over all with the knee in extension and insures no damage from movements while the patient is coming out from the influence of the anæsthetic. On the eighth day the cast may be removed and the superficial stitches taken out. On the tenth day the deep stitches are removed; function is permitted as soon as the patient desires it.

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# REPORT ON THE USE OF HYCLORITE AND A MODIFIED DAKIN'S SOLUTION AS A SUBSTITUTE FOR THE ORIGINAL DAKIN'S SOLUTION

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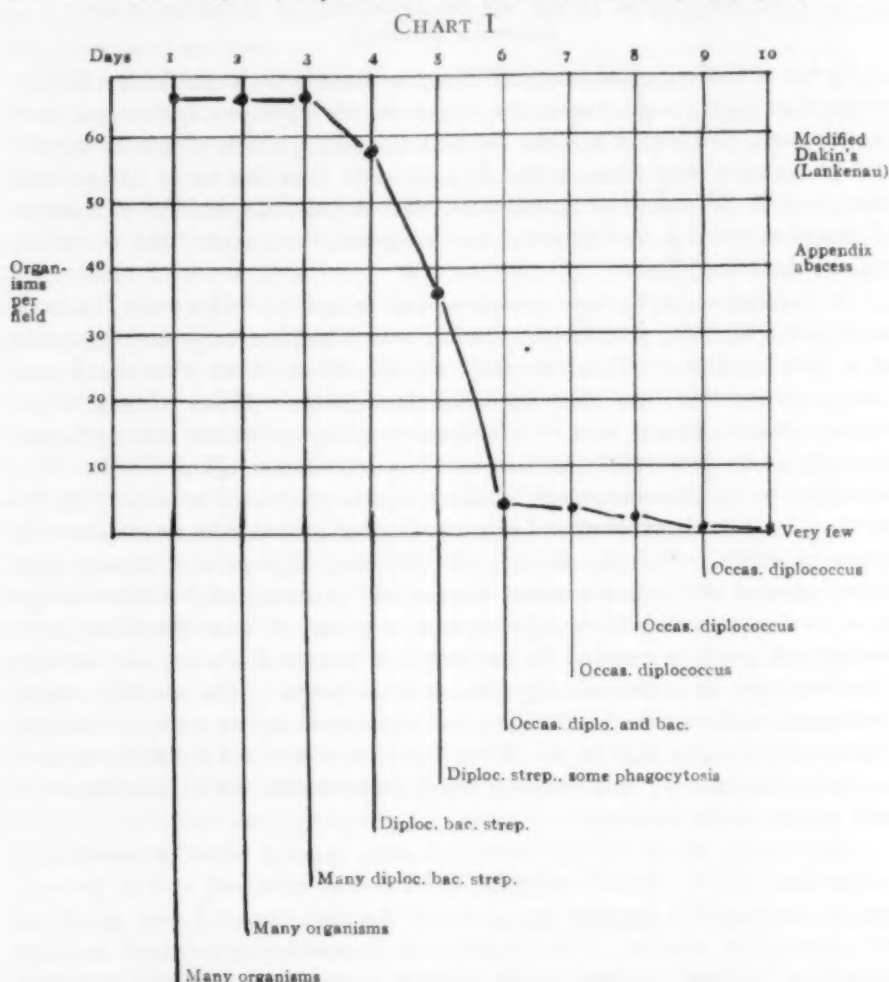
IN an active surgical hospital there is always a demand for efficient antiseptics. Of recent years, the hypochlorite solutions have come into prominence, and enjoy a wide reputation, and quite a range of applicability. Dakin's solution is the hypochlorite solution most extensively used, and is the solution which was used in this hospital for a number of months—until a modification was adopted, the preparation of which will be described later.

In November, 1919, our attention was drawn to "Hyclorite," a concentrated sodium hypochlorite solution which had recently been accepted as a new and non-official remedy by the Council of Pharmacy and Chemistry of the American Medical Association. Since this solution seemed easy to dilute, was of a standardized hypochlorite strength, and was said to be very stable, its use was begun in the surgical wards. The hypochlorite solution supplied by the hospital pharmacy was used in the controls, and both subject and control insofar as possible were identical types of cases. For the most part, draining appendix abscesses and other infected abdominal wounds were used. Although the shortcomings of wound-smears and bacterial counts as a gauge of wound-healing were recognized, yet it seemed to be the simplest means of tracing our results. Consequently, at each dressing smears were made of the wounds under treatment, and examined. At the same time, close touch with the clinical aspects of the cases was kept. Several typical charts are appended which are self-explanatory, and indicate the factors which were considered in each of the series studied.

After using Hyclorite for several weeks, inquiry into the method of preparation of the Dakin's solution used in our controls, and in general use throughout the institution, revealed the fact that the two solutions are remarkably similar. The demand for hypochlorite solution in large quantities led the pharmacist to digress somewhat from the standard method of preparation, substituting  $\text{NaCl}$  for  $\text{NaHCO}_3$ —using the  $\text{NaCl}$  in such quantity as to produce an 0.85 per cent. strength in the finished product. It was thought that by this means the free carbonates could be eliminated, and the solution thus rendered more stable. The fact that a sample of this solution, recently titrated after a year and three months standing in a corked brown bottle, showed infinitesimal loss of available chlorine, justified the hopes of a more stable preparation. As no adverse criticism of this solution was forthcoming, a "stock solution" was made

in order that there might be an economy in time and labor, as well as bulk. Thereupon a solution was made containing five times all the components except water, and the dilutions made 1:4 with water as required. Since there are nearly 30 quarts of this modified Dakin's solution used daily, it will be seen that some such method is justifiable.

*Method of Preparation and Titration; Results.*—The method of testing the two solutions, *i.e.*, Hyclorite and modified Dakin's, is identical. In



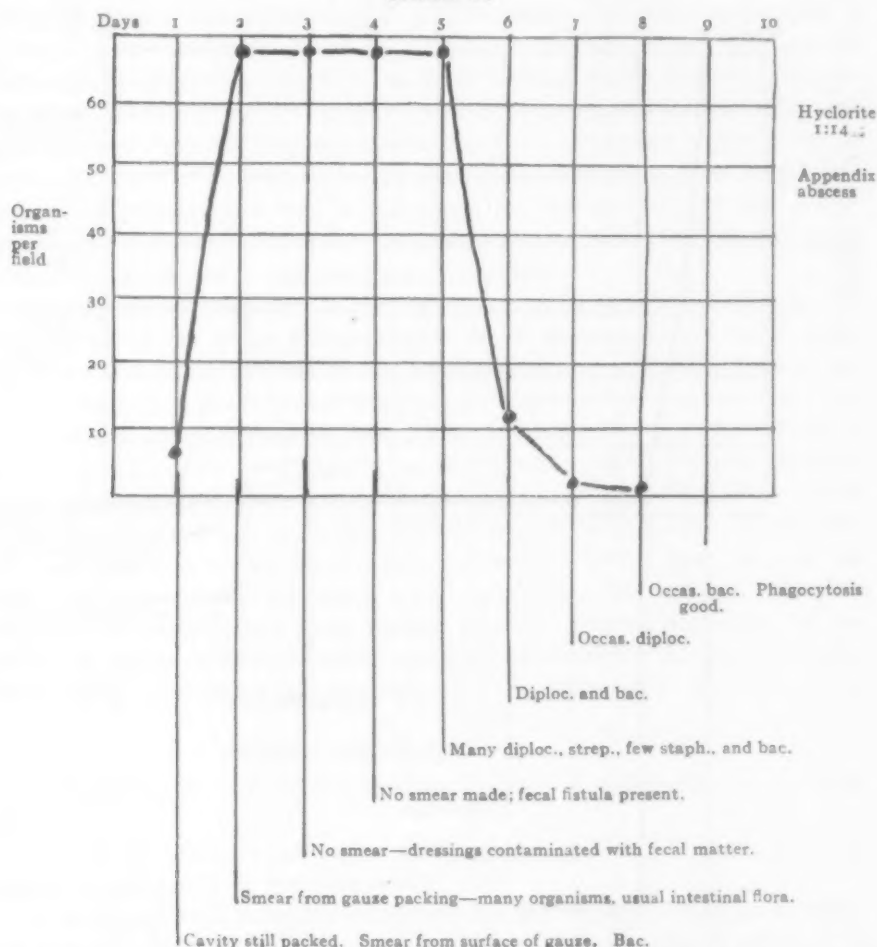
preparing and testing our own solution, the original technic of Daufresne is followed, except as noted above—the substitution of NaCl for  $\text{NaHCO}_3$ . We have frequently titrated fresh and twelve-hour-old solution of Hyclorite and our own modified Dakin's, and find that the two solutions in proportionate dilutions titrate practically the same, the Hyclorite showing slightly more available chlorine than the modification. Neither solution shows any appreciable loss of strength after standing over night in an open graduate; each shows a very small calcium content,

## THE HYCLORITE ANTISEPTIC

and the same alkalinity. In this connection too much stress cannot be laid on the testing of the chlorinated lime used in the preparation of the solution. Assay of this ingredient as it comes to the hospital shows a variance from 9 to 40 per cent. chlorine. The chlorinated lime of the U.S.P. should assay 30 per cent. chlorine, and any excess or deficiency must be corrected as shown in the "Table of Ingredients."

*Methods of Using.*—"Hyclorite is used in dilution of 1:7 when an

CHART II



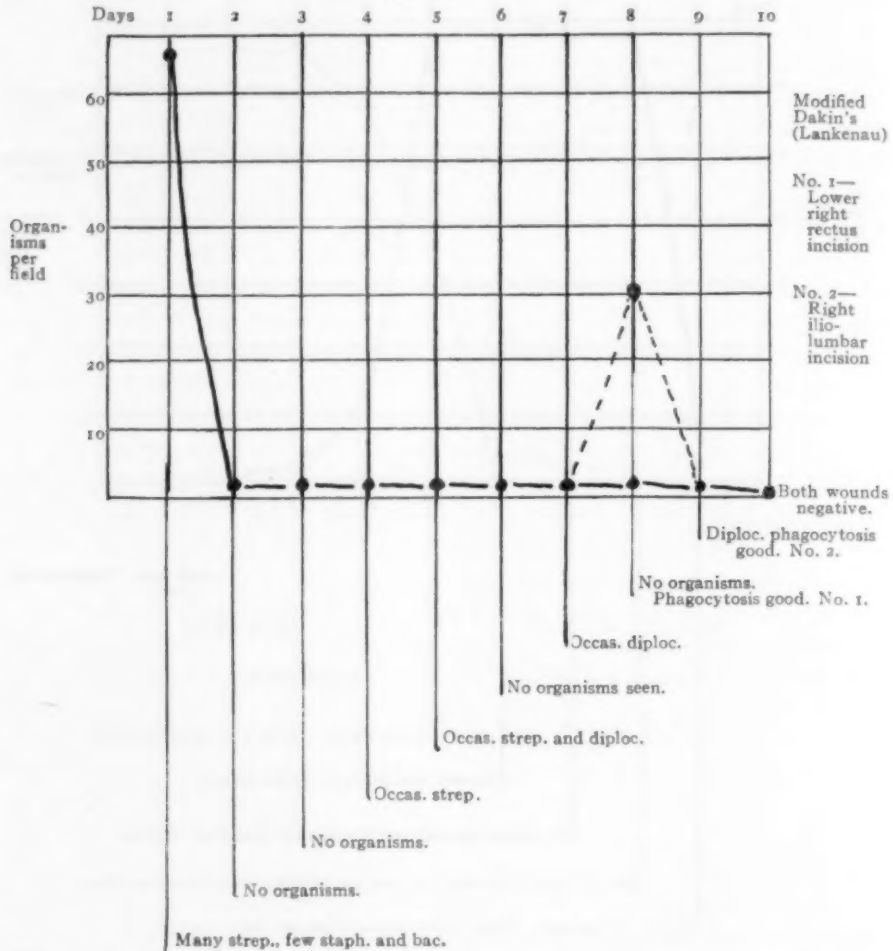
irrigation is needed which corresponds to Carrel-Dakin solution. The dilution is made in the dressing-room immediately before using. The modified Dakin's is dispensed already diluted, *e.g.*, 1:4 of the "Stock Solution" with water.

Stock solution is now dispensed to all the surgical wards in corked brown bottles. Thus Hyclorite and our modified Dakin's can be used full strength, or in any dilution required, by mixing immediately before using. When either solution is used full strength, it is applied on a

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cotton swab. In dilutions of 1:3, 1:7, 1:14, 1:20, 1:500, and 1:1000, the ordinary gravity irrigating apparatus may be used, or the original technic of Carrel. However, we have found it to be quite as effective to loosely pack the wound with gauze laid around Dakin's tubes and allow the ends to protrude from the dressing. In this way, the gauze may be kept moist by injecting the solution in desired strength, by inserting the nozzle of a glass syringe into the ends of the tubes.

CHART III



SUMMARY OF RESULTS

For the purpose of example and of explanation, three charts are shown, representing respectively three series of cases: Series 1, simple recovery; Series 2, complicated recovery; Series 3, complicated recovery with secondary operation.

Clinically, we have found that in irrigating infected abdominal wounds with a dilution of 1:7 Hyclorite, or 1:4 of our modified Dakin's

## THE HYCLORITE ANTISEPTIC

there is apt to be considerable irritation, and dilutions of 1:4 and 1:8 respectively, are more to be preferred, especially if no slough or dense layer of pyogenic membrane is present to protect the nerve endings. Full strength of either solution applied to devitalized or sloughing tissue is remarkably efficient, and it is superior to silver nitrate and other caustics, in our opinion. Used for this purpose it should be applied with a cotton swab, and the healthy tissue protected with gauze. We have used a dilution of Hyclorite 1:3 in an empyema cavity which was discharging freely one month after thoracotomy. In this case such a strength was justifiable, since its antiseptic properties and perhaps its caustic or proteolytic properties could act without much danger of breaking down nature's barrier membrane. In this case, furthermore, the solution was made weaker as soon as the bacterial count began to come down. In another empyema, 1:500 Hyclorite irrigations were begun immediately after operation, and in four days the solution returned clear. The patient was discharged from the hospital and returns to the dispensary for treatment. Progressive improvement is reported.

As soon as the infection is cleared up clinically, and no organisms are reported from the smear examinations, the irrigations should be stopped, for in several instances, where we have thought to stimulate granulation in such wounds, a small, non-granulating or senile wound has resulted. We have diluted our solutions as soon as the infection is controlled—thus in the case of Hyclorite, from 1:3 to 1:14, and finally 1:500. We have observed a rise of temperature in two instances (Mrs. D. and Mrs. B.), where Hyclorite was used as an irrigation of abdominal wounds. There was no other apparent cause for the phenomenon in either case, and as the irrigation was done very soon after operation, we assume that the pyogenic membrane had been broken down in places, allowing the entrance of organisms and toxins into the lymphatics. At any rate, discontinuance of the irrigations resulted in immediate fall of temperature.

### CONCLUSIONS

1. Hyclorite is indicated wherever Dakin's is indicated (in dilutions of 1:7).
2. It is of value when applied full strength and 1:3 in chronically infected wounds, and to dissolve slough.
3. It should be a valuable antiseptic for use in office work or in treating a few patients, because of its stability, and its ease of dilution to various strengths.
4. For large institutions requiring large quantities of a hypochlorite solution, the modification of Carrel-Dakin solution as prepared at this hospital answers every purpose, being more staple than that prepared by the Daufresne technic, and far more economical than Hyclorite.
5. The "Stock Solution" (as prepared at this institution) fills every requirement in which full strength Hyclorite might be used, being only slightly weaker in available chlorine.

## A GASTRO-ENTEROSTOMY CLAMP SIMPLIFIED AND IMPROVED

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SEVERAL years ago while assisting a well-known surgeon in performing a gastro-enterostomy certain extraordinary conditions presented themselves rendering the operation extremely difficult. The laparotomy was performed through an unusually thick abdominal wall and after revealing a duodenal ulcer, the application of the usual Roosevelt clamp to the stomach and the jejunum was attempted, but a tremendously thickened transverse mesocolon rendered the procedure practically impossible, and after several futile attempts it was given up. Almost nonplussed by this combination of conditions, the operator, whose experience in stomach surgery is as great as that of any man living, was finally compelled to perform the operation without clamps in a welter of blood and intestinal contents.

Although our patient made an excellent recovery, the extreme difficulty of the operation made an indelible impression on my mind, and some years later, when I had acquired an operating room of my own, a somewhat similar case occurring with all its attending problems of technic, vividly recalled the earlier experience. I then resolved to devise some type of a clamp which I believed would be more satisfactory than those in general use and I take this occasion to present an instrument which I have been using for some time with great satisfaction.

Gastro-enterostomy was first performed successfully by Wolfier at the suggestion of Nicoladini in 1881. It was an operation in which little confidence was placed, for stomach patients were usually treated medically until moribund, and surgical treatment was utilized only as a last resort. The mortality was high in the operations performed prior to 1885, averaging over 65 per cent. Every sort of mechanical device imaginable was used in the earlier operations, but it was not until the posterior operation of Von Hacker was described that the gastro-enterostomy clamp, such as we understand it to-day, came into general use. For many years the operation was performed with a pair of separate clamps, these finally being supplanted in the hands of many operators by the combined clamp of the Roosevelt or Linnartz type. Even to-day there is no uniformity about the technic of the operation and no one type of instrument has universal popularity. One surgeon will proceed with a pair of Lane gastro-enterostomy forceps or a pair of Kocher resection forceps. The next will prefer the Linnartz or perhaps the combination of two Mayo-Robson forceps. The Thomas intestinal clamp is used by some, the Moynihan clamp by others, while still other thoroughly capa-

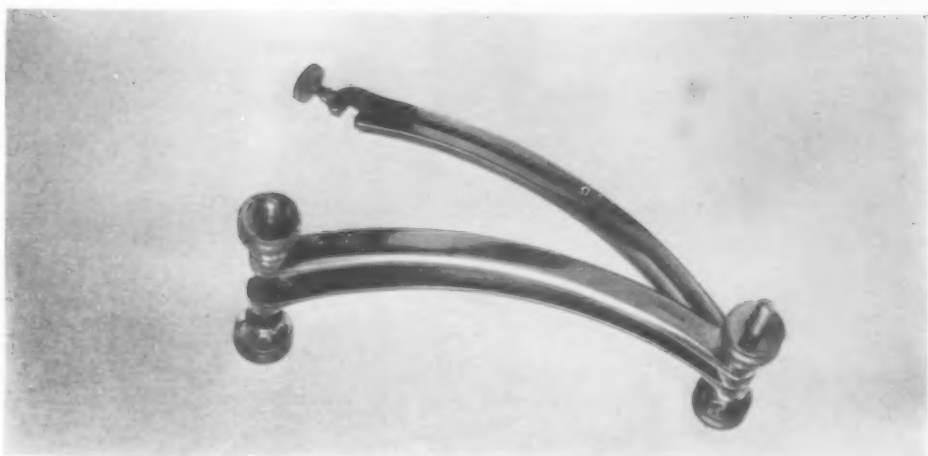


FIG. 1.—Gastro-enterostomy clamp.

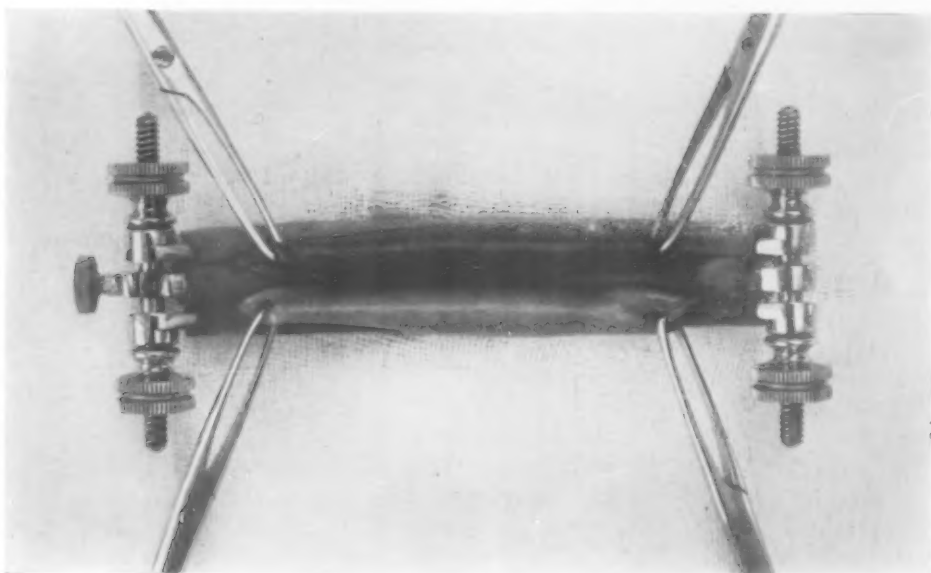


FIG. 2.—The clamp in place; portions of stomach and jejunum being adjusted within the jaws.

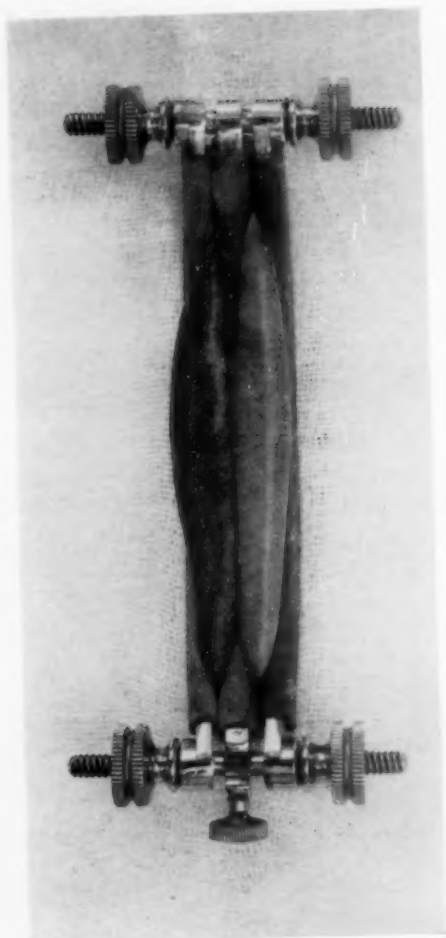


FIG. 3.—The clamp fully adjusted; note the control of equable pressure by the four set screws.



FIG. 4.—The operation completed, the instrument unlocked, the side bars swung back and the centre bars ready to be disengaged.

## SIMPLIFIED GASTRO-ENTEROSTOMY CLAMP

ble operators will elect to perform the operation with a Bartlett aluminum clamp, with the Scudder fenestrated stomach forceps or with the Payr flexible intestinal clamp. Murphy used no clamp whatever, but performed the operation with the aid of a rectangular button. Some surgeons will use no mechanical device as an aid. As a general thing, however, the operation can be far more perfectly performed with the aid of some device which will satisfactorily control the hemorrhage and the flow of gastric and intestinal contents. An instrument which will do this and at the same time will steady and support "the work," as an engraver would say, will prove of value to any surgeon and is bound to make the operation more satisfactory and far easier of accomplishment than if it were performed without such aid.

The Roosevelt clamp accomplishes nearly everything that can be desired of a gastro-enterostomy instrument, and although its popularity is thoroughly justified and it is probably the most widely used instrument of all, yet it has its defects. It is impossible to maintain an equable pressure through the length of its jaws. It has a pair of long weighty handles that drag upon the stomach and intestines. The pressure upon the stomach and bowel is controlled only at two points when it should be adjustable at four and, because of its peculiar construction, the pyloric portion of the stomach is occasionally prone to slip from its grasp.

In the experimentation performed with various models and which has resulted in evolving the instrument I am at present using, the attempt has been to produce a light, easily applied, accurately fitting clamp producing an even parallel pressure between its jaws and so arranged that this pressure may be accurately adjusted to a nicety at four points. Ease of removal at the completion of the operation has also been a factor considered in designing the instrument. The clamp has the general shape and curvature of the Roosevelt, as will be seen (Fig. 1). It consists of a central bar and two side bars controlled by four knurled nuts. The central section is slotted to receive a square shoulder cut at the centre of one of the transverse screws and held in place by a small set screw. The two side members can be swung through a circle of 180 degrees, facilitating the rapid removal of the instrument on the completion of the operation. The instrument is constructed of steel except for the nuts, which are of brass, and for the screws which, double threaded, are of Monel metal to prevent corrosion. In using the instrument rubber tubing is first slipped over the three sections as is done with the ordinary Roosevelt clamp. Portions of the stomach and jejunum are approximated and are drawn through the instrument by means of Allis forceps, as shown in Fig. 2, or by means of traction sutures. Delicate adjustment of the stomach and bowel can be brought about with great facility and accuracy with this apparatus, the application of the pressure being readily under the control of the four screws. Fig. 3 shows the stomach and the jejunum approximated and secured in the clamp ready for the first row of serous sutures.

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Fig. 4 shows the operation completed, shows the instrument unlocked, the side bars swung back, and the centre bar ready to be slid from beneath the anastomosis. The early models were hand forged for me by Harvey R. Pierce & Company, of Philadelphia, and recently the completed instrument has been placed in stock by that manufacturer.

TRANSACTIONS  
OF THE  
NEW YORK SURGICAL SOCIETY

*Regular Meeting, Held February 25, 1920*

The President, DR. WILLIAM A. DOWNES, in the Chair

DEPRESSED FRACTURE OF THE SKULL, HÆMIPLEGIA, RECOVERY

DR. FREDERICK T. VAN BEUREN presented a boy ten years of age who was admitted to the Roosevelt Hospital November 10, 1919, at 10.30 P.M., with the history that while walking along the street something had fallen and struck him on the head. At the time of admission he was conscious and no paralysis was noted. There was free bleeding from the scalp wound. The temperature was 99° F., pulse 120, and respirations 32. There were clonic spasms involving the right arm and leg, slight in degree and lasting about ten minutes. Motion and sensation were normal so far as could be determined. There were no pupillary symptoms, no facial paralysis, and the knee-jerks were present and normal.

There was a depressed fracture of the vault of the skull over locomotor area of brain. Immediate operation was performed, with the patient under ether anæsthesia 45 minutes and in the prone position. The depressed fragments were elevated and removed, with extreme care, after debridement of scalp. The depression had a diameter of about 3 cm. and a depression of about 1 cm. The inner table was fractured to a considerably greater extent. Although great care was exercised in the removal of the fragments by cutting around them with rongeur, the dura was found to be lacerated, the laceration being linear and extending from before backward. As the dura pulsed normally it was not opened. The wound was closed, leaving a small area in the centre for drainage. The boy was sent back to the ward in good condition. The following morning there was voluntary paralysis of the right arm and paræsthesia. Sensation of pain, pressure, touch, position, heat and cold were present, but slowed down in perception. The reflexes were diminished at the elbow and wrist. Passive motion was sometimes faintly opposed by involuntary action. Sensation and motion in the right leg were normal.

Doctor Tilney was then called in on November 12th to examine the boy and noticed a slight flattening of the right side of the face. There was complete loss of voluntary motion in the right arm; the reflexes absent included the biceps, triceps, pectoral and wrist. The left arm was normal in strength and reflexes. The abdominal reflexes were active and equal. Knee-jerks were more active in the left than in the right leg. There was no Babinski

or clonus. The strength of the right leg was less than that of the left. Sensation was normal. The pupils were active and contracted to light. The tongue protruded in the mid-line.

On November 14th the reflexes were still absent in the right upper extremity, and it was slightly spastic. There was an increase in strength in the right leg, but no changes in the reflexes.

On November 18th, eight days after the operation, the nurse noticed slight active movement of the right arm while massaging it. Movements were awkward and fumbling and stronger in flexion and pronation than in extension and supination. The following day they had improved slightly in strength and purposefulness, but were still quite feeble and poorly coördinated. The patient looked brighter and had improved in general appearance. There was still a slight right facial paralysis, barely noticeable except in the branch to the lower lip. The movements of the head and neck were apparently comfortable and quite free. The tenderness and oedema of the scalp had practically disappeared. The discharge from the wound which had been free from the second or third day post-operative had become much less and the defect in the wound was smaller. There was still some sloughing and granular material in this fluid could be expressed from beneath the lower flap. The right arm, though still held in flexion at the elbow and with pronation of the forearm, was capable of almost all motions in some degree. Flexion of the fingers was poor and extension very poor, being spasmodic and incomplete, and adduction and abduction were absent. All the movements were poorly coördinated, irregular in degree, and could not be sustained. Reflexes and sensation were practically normal. The reflexes of the right leg were normal and the strength almost equal to that of the left leg.

On November 19th the triceps and biceps reflexes of the right arm were all present and also those of the wrist and ulna. There was very slight ankle clonus of the right leg, and the strength was nearly normal. The fingers could be moved in flexion and extension. There was a slight degree of wrist drop of the right hand. Flexion and extension of the right forearm was also noted.

On November 21st the finger movements had distinctly improved. The movements of the index and middle finger phalanges were almost completely regained, and the other movements were growing stronger.

November 23rd the action of the interossei, previously absent, could be noted, though it was incomplete. The extension of the fingers was much better; the fourth and fifth fingers could be extended. Extension of the wrist which was almost absent three days before had markedly improved. All motions were much better coördinated.

He was discharged from the hospital December 10th, and had continued to improve until the residual loss of motion was very slight, amounting, three months after injury, to inability to adduct the little and index finger of the right hand. Motions are still a little awkward and strength of the right hand a little less than normal.

## GASTROJEJUNAL ULCER

Examination of the site of the injury shows the existence of a very large defect of the cranial wall. The boy would require very careful watching, especially as there had been laceration of the dura, on account of the possible subsequent development of Jacksonian epilepsy.

## TUBERCULOUS TUMOR OF CAPSULE OF KNEE

DR. HAROLD NEUHOF presented this patient, a woman, twenty-eight years old, who came under observation six years ago with an enlargement about the knee-joint of one and a half years' duration. There was a considerable effusion into the joint with marked limitation in motion. The striking feature was a large painless mass deeply situated under the vastus internus and apparently contiguous with the joint. Aspiration of the joint disclosed clear fluid which was negative upon animal inoculation. X-ray examination showed the picture of a chronic osteo-arthritis. The preoperative diagnosis was a fascial sarcoma.

At operation in February, 1914, a longitudinal incision was made over the mass under the vastus internus, which upon exposure was interpreted as a neoplasm springing from the joint capsule. This was widely excised. The synovial membrane of the joint being freely sacrificed about the tumor to which it was adherent. No lesion was seen within the joint itself other than a rather spongy appearance of the synovial lining. The wound was closed in layers.

A microscopic examination of the specimen showed a typical tuberculosis of fibrous type. The attached portion of the synovial membrane was free from any microscopic evidence of tuberculosis. An immobilizing splint was employed, with interruptions, for about a year and was then discontinued. There is now moderate limitation in flexion and extension of the joint, and a recent X-ray shows a slight degree of chronic osteo-arthritis. Occasional pain after standing for long periods is the only symptom of which the patient complains. At no time has there been any evidence of recurrence or of tuberculous involvement within the knee-joint.

## GASTROJEJUNAL ULCER

DOCTOR NEUHOF presented a young man, aged twenty-four years, who came under observation in Bellevue Hospital in April, 1919, with a history of pyloric stenosis of many months' duration. Because of the extreme emaciation a provisional diagnosis of pyloric carcinoma was made. At operation, a transverse abdominal incision was made. There was a large saddle-shaped ulcer of the pylorus, extending into the first portion of the duodenum. The pylorus appeared completely stenosed. The stomach was greatly dilated and atonic. The general condition of the patient appeared too poor for excision and a posterior no-loop gastrojejunostomy was made. The usual four-layer suture was employed, chromic gut for the inside and fine linen thread for the outside. The transverse mesocolon was fixed to the gastric wall in the usual way. Convalescence was

smooth after operation, vomiting ceased and the patient rapidly gained weight and strength. He felt perfectly well until five months after operation.

Epigastric pain then began, occasionally accompanied by vomiting. These manifestations became more severe and the patient again began to lose weight. X-ray examination showed a patent gastrojejunostomy but considerable retention as well. There was a second operation in October, 1919, that is, about five months ago. At operation, through a vertical abdominal incision, only a small area of induration was found at the pylorus where previously the saddle-shaped ulcer had been. The pylorus was partly open. The mesocolon was contracted about the gastrojejunostomy, apparently as a result of the adjacent inflammation. At the gastrojejunal stoma, there was a large area of dense infiltration with crater-like margin almost exclusively situated in the wall of the stomach. It completely, or almost completely, encircled the anastomosis, extending only slightly into the jejunum. The largest diameter of this ulcer was about 8 cm. The stoma appeared patent, but to what degree could not be determined. The gastric wall was uninvolved beyond the sharp confines of the ulcer.

Several alternative procedures offered themselves for the treatment of the condition that was encountered: First, to sever the anastomosis, excise the ulcer, and reimplant. This was rejected because of the extensive size of the ulcer and shortened mesocolon, and also because of the general condition of the patient. Another procedure was to divide the jejunum at both sides of the anastomosis and reimplant. This was thought to be too difficult because of the very short afferent portion of jejunum. The following procedure was employed: A long loop anterior gastro-enterostomy was done, chromic gut sutures being used throughout; the anastomosis was placed near the greater curvature and to the pyloric side of the gastrojejunal ulcer. The length of the loop was about 25 cm. The entrance of the afferent portion of jejunum into the posterior gastro-enterostomy was then occluded by a silk ligature tied tightly in place. The efferent portion of the jejunum from the old anastomosis could not be treated in a similar fashion because of the possibility of regurgitation into it from the anterior gastro-enterostomy. At the same time it appeared desirable to avoid regurgitation from the new into the old anastomosis. In the effort to avoid this and to avoid as well stasis in the duodenum, a side-to-side anastomosis was made between the ascending limb of jejunum going to the new anastomosis and the portion of the jejunum to the proximal, that is, gastric side, of the occluding silk ligature. A Murphy button was used for this purpose. Convalescence after operation was smooth. Only after operation was concluded did the writer consider the fate of the Murphy button. It then appeared to be inevitable that the button would be passed into the stomach. However, by good fortune the button was passed in the stool on the ninth day. Pain disappeared shortly after operation and has at no time recurred. Vomiting has not recurred. Appetite is good and the patient has gained steadily in

## SPINAL CORD TUMOR

weight. There has been no gastric retention in the examinations made since operation, and the patient appears entirely well at the present time.

DR. JOHN F. ERDMANN said a point of interest in this case was the excision of an ulcer at the second operation. He had fortunately or unfortunately had to do quite a number of revisions following gastro-enterostomy. This was because some of these subjects were ulcer bearers, and no matter how thoroughly an ulcer was excised there would be a recurrence. He recalled one instance in which he found an ulcer at the first operation and did the Polya operation. Subsequently there was a recurrence and he did a resection of the jejunum at the anastomosis site, then a jejunojejunostomy, and a gastrocolostomy; later there was another recurrence. In another patient he had operated at three different times for recurring peptic ulcer in the immediate vicinity of a gastrojejunostomy opening. Some ten or twelve similar cases had come under his observation, one in which the colon, jejunum and stomach were all anastomosed. Some of these ulcer cases were certain to have recurrences in the course of eight or twelve months. As to suture material for five or more years he used absorbable suture material, chromic catgut, altogether, except in the transverse mesocolon.

DOCTOR DOWNES said he had reported two cases of gastrocolic fistula following gastro-jejunostomy some time ago. In one of the cases, in attempting to separate the colon from the stomach and jejunum, he found he had removed so much of the jejunum that it was necessary to do an end-to-end anastomosis, and he wondered whether or not Doctor Neuhof could not have done a resection. Doctor Downes said he was afraid if there should be a recurrence in Doctor Neuhof's case he would have considerable difficulty in getting things straight.

DOCTOR ERDMANN said that when he first attempted the revision following a gastro-enterostomy for peptic ulcer in the vicinity of the gastro-enterostomy opening, the procedure looked like a rather formidable undertaking, but after having done it once he found it very easy and rather enjoyed that type of operation now.

## SPINAL-CORD TUMOR

DOCTOR NEUHOF stated that this patient, forty-seven years of age, had had what he described as rheumatism about the left shoulder for some eight years. About fifteen months ago (November, 1918) he began to experience lancinating pains in the third, fourth and fifth fingers of the left hand. Subsequently there was similar pain down the left lower extremity. He then noted difficulty and stiffness in walking with dragging of the left leg. Difficulty in urination developed at a later stage. All the symptoms were progressive, especially the pain radiating into the left hand.

A résumé of the physical examination upon admission to the Montefiore Home consisted in unequal pupils, the left smaller than the right; atrophies in both upper extremities, chiefly in the left hand; spastic gait with exaggerated and abnormal reflexes, ankle and patellar clonus. The interesting feature

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of the neurological examination was the vague and indefinite level area of hyperalgesia which was varyingly located from the upper cervical to the upper dorsal segments at examinations made at different times. Lumbar puncture established the indication for operation, for a yellow fluid was withdrawn which promptly clotted on standing.

At operation, on September 18 (five months ago), the spines and arches of the fourth, fifth and sixth cervical vertebræ, and subsequently those of the third and seventh, were removed in the usual way. Upon opening the dura, a cystic portion of the tumor at once presented. Posterior roots could not be seen and for some time it was difficult to determine whether or not the tumor was an intramedullary one that had broken through the cord. By gently tugging on the cystic cap of the tumor the upper pole was dislodged from underneath the arch of the second cervical vertebra. The lower pole could then be dislocated and the whole tumor slipped free. It manifestly arose from the pia-arachnoid. Its attachments were two posterior roots that were sacrificed and a vascular pedicle springing from the posterior spinal vessels. This was tied off. Nevertheless, the base of the pedicle oozed freely. Bleeding was promptly controlled by a postage stamp graft of a small fragment of muscle. The cord was found extensively flattened, more so on the left than on the right side. Wound was closed in layers in the customary manner, and a board splint applied.

The tumor was unusually large, 8 cm. long and about  $2\frac{1}{2}$  cm. in diameter. It presented a number of cystic excrescences and for the rest was of jelly-like consistency. Upon section the cysts were found to be occupied by clear or bloody fluid. Microscopic examination showed an endothelioma with cystic and hemorrhagic degeneration.

Convalescence was smooth. The patient was immediately free from the pain of which he had complained and has remained free up to the present time. There has been gradual improvement in power in the left arm and hand. The right upper extremity is practically normal, and there has been marked improvement in the spasticity of the lower extremity. Urination is normal. There is no discomfort following removal of the cervical bony arches.

The interesting feature is the large size of the tumor producing relatively slight manifestations because of its semi-fluid consistency.

## OSTEO-ARTHRITIS

DOCTOR NEUHOF presented a man, aged forty-eight years, whom he wished to show in connection with the question recently raised at this society of early mobilization after knee-joint operations, as well as to indicate the possibility of operative relief in some cases of osteo-arthritis. Operation had been done too recently to consider the possibilities of the ultimate result. The patient complained of pain and stiffness in the right knee which began about a year ago. The symptoms had become progressively worse, the patient soon being unable to stand any length of time. Pain was always increased by attempted motions at the joint. Treatment consisted in mas-

## SARCOMA OF THE STOMACH

sage, bakings, and vaccines for supposed focal infection in the teeth. Extensive dental work was carried out.

Physical examination at the time of admission to Bellevue Hospital showed the joint considerably enlarged and tender. There was about three degrees of motion up to extension of approximately 160 degrees. Over the inner aspect of the knee the skin appeared drawn in upon flexion of the joint, leading to the assumption of some limiting bands within the joint. The X-ray showed the picture of a chronic hypertrophic osteo-arthritis. An exploratory arthrotomy was suggested, an etiological diagnosis not having been made.

At operation, one month ago (January 25th), a long curved incision was made just mesial to the inner border of the patella. The patella was retracted externally, but could not be dislocated beyond the femur and flexion of the joint could not be carried out. The disease within the joint was almost entirely limited to its inner aspect. The synovial membrane was thickened and discolored, but smooth. The inner border of the patella was sharply lipped. Grayish excrescences of the tibia and femur were visible through the synovial membrane. The menisci were not diseased. The most striking feature of the joint pathology was a broad band of adhesions extending from the tibia, anterior to the crucial ligaments, to the intercondylar notch of the femur. Upon attempting flexion of the knee this was put upon the stretch, and only after its excision, free flexion of the knee with dislocation of the patella were possible. The ligamentum alaria was converted into a thick fibrous mass covered by many pedunculated villi. It was almost completely excised. There were many other pedunculated and sessile villi which were excised. The lipped internal border of the patella was removed with rongeurs. The wound was then closed in layers, and a posterior moulded splint applied.

Passive motion was begun the day after operation, and on the second day active motion was begun. This was increased by the patient under careful supervision. The splint was discontinued after one week. Patient was permitted to walk three weeks after operation. He is now free from pain, walks considerable distances, not using a cane for support. At the present time flexion exists to 90 degrees and extension to about 160 degrees, without any discomfort within this range of motion. The range of motion is progressively increasing.

## SARCOMA OF THE STOMACH

DR. JOHN DOUGLAS read a paper with the above title, for which see page 628.

DOCTOR ERDMANN recalled that ten or possibly eleven years ago, he had removed a sarcoma of the stomach and at the same time removed a section of the ileum for sarcoma. The pathologists were not satisfied as to which growth was primary, the one in the stomach or the one in the ileum. The patient was brought for a beginning intestinal obstruction, and a large sized tumor was found partially obstructing the lumen of the ileum. A resection

was done six or eight inches above the ileocaecal valve. In the course of further exploration at the time of operation the growth in the stomach was discovered. Within a week or two he had heard that this patient had died recently and from what he had heard he understood that influenza had caused his death.

A second patient was a male, aged forty-six years, a prominent actor, from whom he removed about one-half the pyloric end of the stomach for an exogastric sarcoma. This patient was operated upon about six years ago, and died recently of what Doctor Erdmann was unable to report.

DOCTOR FISCHER presented a specimen of sarcoma of the stomach which was removed from a patient forty-four years of age who had never been sick before. Her present trouble first manifested itself only four weeks before she came under observation, when she noticed that her abdomen was increasing in size. She was first admitted to the medical ward and later an exploratory laparotomy was done. It was found that she had a large retroperitoneal tumor, probably originating from the kidney. The condition was inoperable and she died a week later. At postmortem a large sarcoma of the stomach was found. Her blood had shown 70 per cent. hæmoglobin; there was no obstruction of the pylorus, and no anæmia. In fact, there were no clinical stomach symptoms whatever.

*Autopsy Report.*—Upon opening the abdomen 300 c.c. of opaque chocolate-colored fluid escaped. Uterus normal, right ovary and tube atrophic, with cystic degeneration of the ovary. Left ovary absent. Bladder and capsules strip easily, marking slightly accentuated. Spleen: Slightly larger than normal, marked perisplenitis. Liver large, very pale, and waxy and firm on section, with obscure markings. Pancreas normal. With the exception of the stomach, the gastrointestinal tract is normal. Upon opening the abdomen a pear-shaped mass, reddish-yellow in color and semi-fluctuating consistency, presented itself at the usual location of the stomach, but between the leaves of the mesentery of the transverse colon; this mass was subsequently found to measure 21 x 25 x 23 cm. in diameter and to weigh 11 pounds. Upon dissection it was found that the neoplasm had grown from the left wall of the stomach, the greater curvature having assumed the perpendicular position. A circinate ulcer, measuring 5 cm. in its greatest diameter, was found 3 cm. from the pylorus, the base of the ulcer being the tumor previously described. Aside from this ulcer the mucosa of this organ appeared to be normal. On section the tumor was found to be markedly degenerated, with numerous areas of cyst formation. The microscopic examination showed a tumor mass of small spindle cells arranged radially about the small blood-vessels, with many mitotic figures, invasion of the gastric musculature, liver and omentum, and many blood emboli. The anatomical diagnosis was sarcoma of the stomach.

#### ULCERATING FIBROMA OF STOMACH SIMULATING MALIGNANCY

DR. DEWITT STETTEN presented a man, sixty-six years of age, who consulted his physician complaining solely of a feeling of general malaise. He had no gastric or intestinal symptoms and there was no marked loss in weight. A systematic routine examination revealed a moderate secondary anæmia, the blood count being as follows: Red blood-cells, 3,950,000; hæmoglobin, 70 per cent.; white blood-cells, 8,400; polynuclears, 70 per cent.; large



FIG. 1.—Radiograph of stomach shortly after meal, showing persistent defect at greater curvature, indicated by arrow.

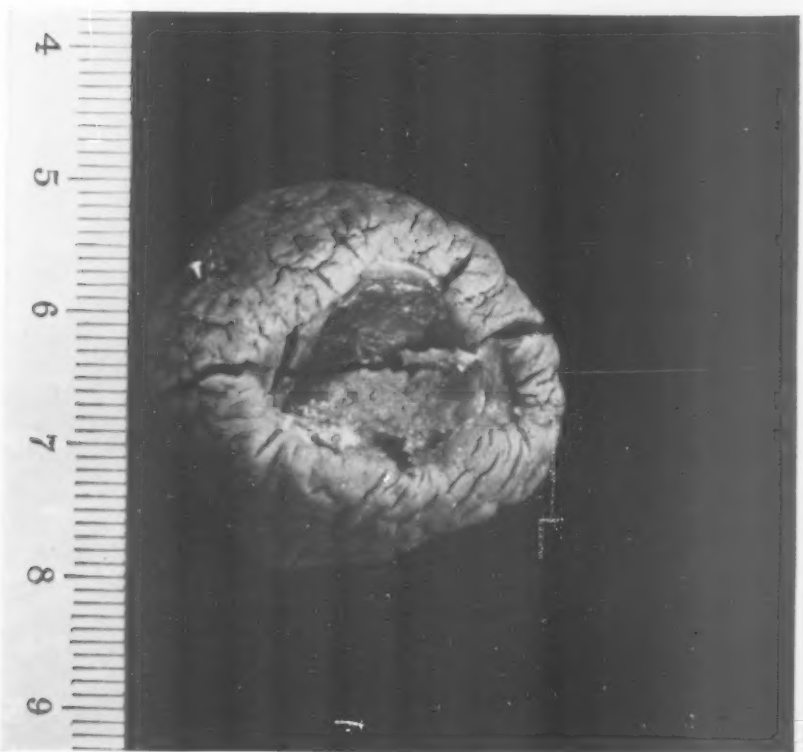


FIG. 2.—Tumor covered by mucosa, showing larger ulceration at apex of tumor.

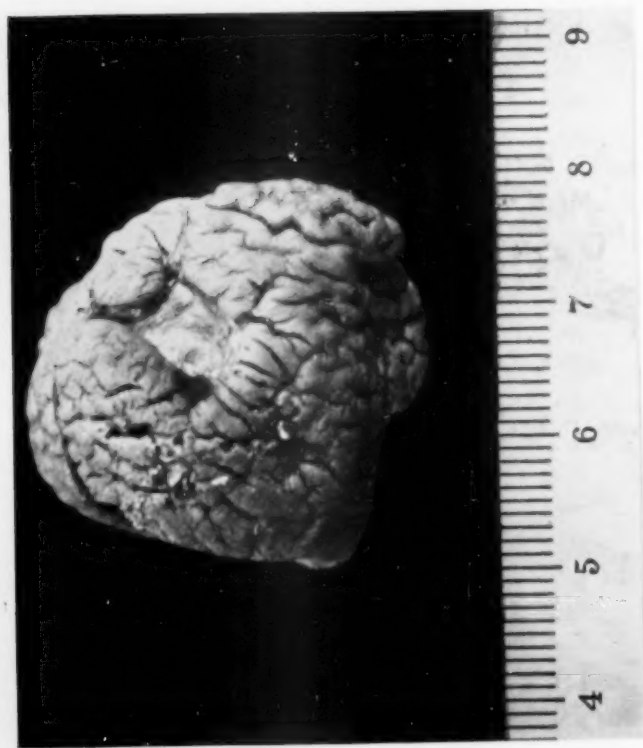


FIG. 3.—Tumor covered by gastric mucosa, showing smaller ulceration at side.

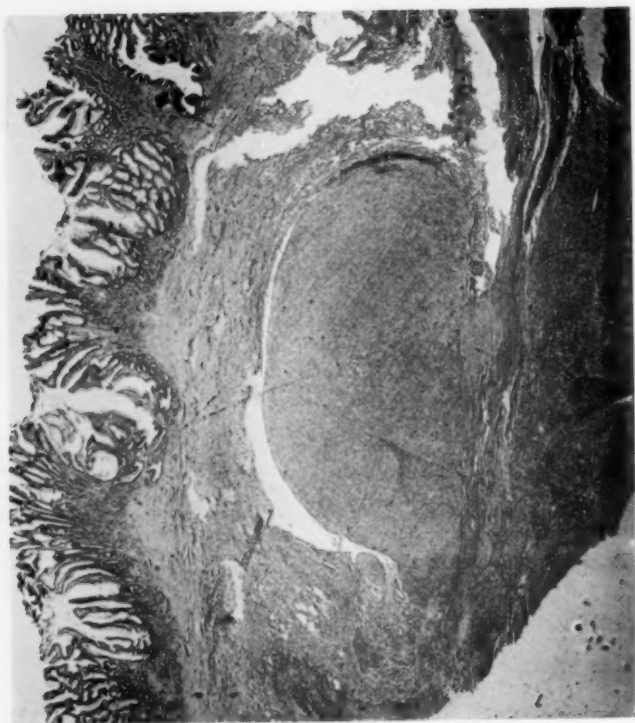


FIG. 4.—Microphotograph from section of tumor. Note position beneath submucosa and character of interlacing bundles of fibrous tissue. Muscle fibres of the muscular coat are seen running through the tumor tissue. Magnified 20 diameters.

## ULCERATING FIBROMA OF THE STOMACH SIMULATING MALIGNANCY

lymphocytes, 4 per cent.; small lymphocytes, 26 per cent. In order to discover the cause of the anæmia the gastro-intestinal tract was carefully gone over. The stool on a meat-free diet showed blood, strongly positive. The string test showed a blood stain 16 inches from the teeth. The gastric contents showed free HCl, 60; total HCl, 84; and blood, positive. A radiographic examination of the stomach showed a definite and persistent defect at the greater curvature, nearer the pylorus. It was of fair size, somewhat triangular in shape and of irregular outline. The sides of the triangle measure about 4 cm. in the plate. The probable diagnosis of malignant disease of the stomach at the greater curvature was made and operation advised.

The operation was performed on January 26, 1917. On inspection the stomach showed no definite evidence of disease. On palpation a slightly pedunculated mass was felt at the greater curvature nearer the pylorus corresponding to the defect shown in the X-ray plate. It was round, hard, rather smooth and about the size of a walnut. There were no glands. It impressed me as a benign growth and I made a wedge-shaped excision and then closed the stomach wound.

The tumor was a hard, rounded mass under the submucosa, and measured about 3 x 3 cm. It had an indistinct, fibrous capsule. On section the tumor presented a firm, somewhat reddened, fibrillated structure. A rather surprising feature was the following: On the apex of the growth a large, round, punched-out ulcer had formed of about 1.5 cm. in diameter and laterally another smaller ulcer, about 0.5 cm. in diameter and of the same character, was discovered. At these ulcerated areas the mucosa was completely destroyed, exposing the tumor.

Microscopic examination of sections of the growth, stained by hæmatoxylin and eosin and by Van Gieson, showed it to be composed of large numbers of interlacing bundles of elongated, fairly mature fibroblasts. The nuclei are in the main rod-shaped. At one point muscle fibres from the muscular coat of the stomach run through the tumor tissue. In places a connective-tissue capsule can be demonstrated. The tumor is undoubtedly benign and must be classed among the fibromata, which according to Aschoff are usually of perineural origin.

The patient made an uneventful convalescence and according to recent report is in the best of health. His living out of town prevented my showing him here this evening.

## CORRESPONDENCE

### FRACTURE OF THE OS NAVICULARE PEDIS

EDITOR, ANNALS OF SURGERY:

Mrs. T. Z., aged twenty-five years, seen first on February 17, 1920, at which time the following history was obtained: The previous night, while leaving the theatre, the heel of the left foot was caught in the runway, causing the foot to twist sharply outward. The patient experienced a sudden sharp stab of pain in the foot, followed by immediate disability, necessitating aid to enable her to reach her home. The next morning I examined the case and noted the following: Left foot presented a distinct, localized prominence over the inner and upper part of the scaphoid. The part was very red and intensely painful and tender. In fact, the symptoms were so marked that no attempt was made to obtain crepitus. A tentative diagnosis of fracture of the navicular was made. The radiographic report (Fig. 1) confirmed the diagnosis and also defined the good apposition of the fragment. Considering this, no further attempt to obtain crepitus was made. A pad of heavy saddler's felt was strapped over the site of injury and a plaster-of-Paris case applied, extending from the toes to midway up the leg. The foot was maintained in a position of inversion and at a right angle to the leg. At present writing the bone shows good union with no subjective symptoms except for a feeling of tiredness when she overexerts the part.

A study of the literature shows how very uncommon this lesion is. Stimson was able to collect a total of seventy cases, including a series of twenty-two, reported by Finsterer. Scudder dismisses the entire subject with the remark that this fracture is caused by direct violence. Walton, writing on fractures and separated epiphyses, barely mentions the topic. Bloodgood, Speed, and Moorhead all speak of this trauma as rare. Moorhead, in his book on Traumatic Surgery, collected a large number of various bone fractures, taken from a number of New York City hospitals. He obtained a total of 5028, of which he states that the tarsus were fractured forty-seven times but does not individualize them. In other words, isolated fracture of the scaphoid was not apparently met with. I say this because of the fact that in a series of 115 cases of fracture, observed by the same writer, in a period of one year, he does list isolated tarsal injuries. (One case of fracture of the cuboid.) In a personal study of the statistics of all the fractures at the Hospital for Deformities and Joint Diseases, for the past two years, I was able to gather a total of 774 cases. No single case of fracture of this bone was found.

Without the aid of X-rays the diagnosis is presumptive, especially so if no displacement of the fragment occurs. Stimson goes so far as to state that two-thirds of the cases are unrecognized, after long intervals,



FIG. 1.—Fractured scaphoid bone of the foot.



## CORRESPONDENCE

until radiographed. An X-ray usually makes for a positive diagnosis. Occasionally, one may be deceived by the presence of the os tibiale externum, one of the supernumerary bones of the foot. The usual sites of fracture of the navicular are through the body of the bone or at the base of the tubercle.

Treatment of this type of injury should be directed toward maintaining the future static function of the foot, particularly so, since this bone is in direct line of weight-bearing. It might not be amiss to recall the fact that attached to the under surface of the navicular is the so-called "spring ligament," commonly known as the inferior calcaneo-scapoid ligament. This structure performs the important duty of supporting the astragalus, thereby acting as the principal mainstay in upholding the longitudinal arch of the foot. An injury severe enough to result in a fracture of the bone, one must assume, will inflict damage on this underlying structure. With this anatomical reason in view, inversion of the foot should be maintained at all times. This position tends to prevent a future traumatic flat foot and at the same time permits of no undue tension on the injured ligament. Inability to maintain reduction of the fragment, when displacement recurs, calls for operative interference. It is good policy to use a corrected shoe, with an elevation of one-quarter of an inch on the inner border of the heel. This will prevent secondary strain.

The final results are good. A small prominence may remain. Six weeks is a fair estimate for full functional recovery.

I. REITZFELD, M.D.  
New York City.

## DUODENAL HEMORRHAGE DUE TO SUTURE

EDITOR, ANNALS OF SURGERY:

The case herein reported merely confirms what is already known, namely, that the use of silk or non-absorbable material in stomach or intestinal surgery is attended with a remote possibility of a serious complication, in the nature of an obstruction, secondary ulcer, or hemorrhage.

The patient, an adult male, in August, 1912, shortly after a hemorrhage from the stomach, submitted to an operation, and was told by his surgeon that an ulcer was found in the duodenum and was turned in by a purse-string suture. January 16, 1913, he applied to Dr. Wm. Gerry Morgan for treatment, stating that he was having tarry stools. He had no pain or retention and his health seemed unimpaired. At this examination the pulse was 96, soft in quality; blood-pressure 130-90; gastric contents showed mucous pus, free HCl 52, total acidity 64; blood.

February 11, 1913, the hæmoglobin was 55, red blood count 5,360,000, white blood count 8500. The urine showed a few casts and a trace of albumen. The röntgenologist reported an incisura and contracted pyloric end of the stomach; cap normal; no six-hour residue. Benzidine test for

## CORRESPONDENCE

blood in fæces was four plus. About one month later the hæmoglobin was 37, red blood count 4,000,000, and white blood count 7000. He went abroad in the autumn of 1913 and returned much better, his hæmoglobin being 81.

In May, 1914, the tarry stools recurred and blood was present in his stools in December, 1914. The patient then passed from under the observation of his physician but returned on December 17, 1917. In the interval he relates he was operated upon, a gastroenterostomy having been done. At the examination in December, 1917, the stools were black, blood present (benzidine test four plus), and the patient anæmic. The hæmoglobin was estimated frequently at this time, and the lowest reading was 24. The patient was losing blood with every movement and growing weaker from day to day. He was removed to Garfield Hospital December 26, 1917, and operated upon the following day.

*Operation.*—High median incision revealed moderate omental adhesions to abdominal wall. The stomach and duodenum were exposed, inspected and palpated, but no ulcer was discovered. The stomach was opened and explored, an especial search being made for a jejunal ulcer, but the gastroenterostomy was patulous and perfectly healed. The stomach was closed without finding the source of the hemorrhage. A re-examination of the duodenum revealed a narrow black object, which on grasping with forceps, proved to be one end of a silk suture about  $1\frac{1}{2}$  inches long. A few shorter pieces were removed. The area did not have the appearance or induration of an ulcer. The pylorus was plicated with chromic catgut and the abdominal wound closed.

The patient has remained well over two years since the silk suture was removed, which would seem to establish a definite relation between the hemorrhage and the suture, but whether the silk maintained an ulcer, acting as an irritant, or whether the gradual unfolding of the duodenum was lacerated by an unyielding suture matters little in the final deduction.

CHARLES S. WHITE, M.D.,  
Washington, D. C.

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